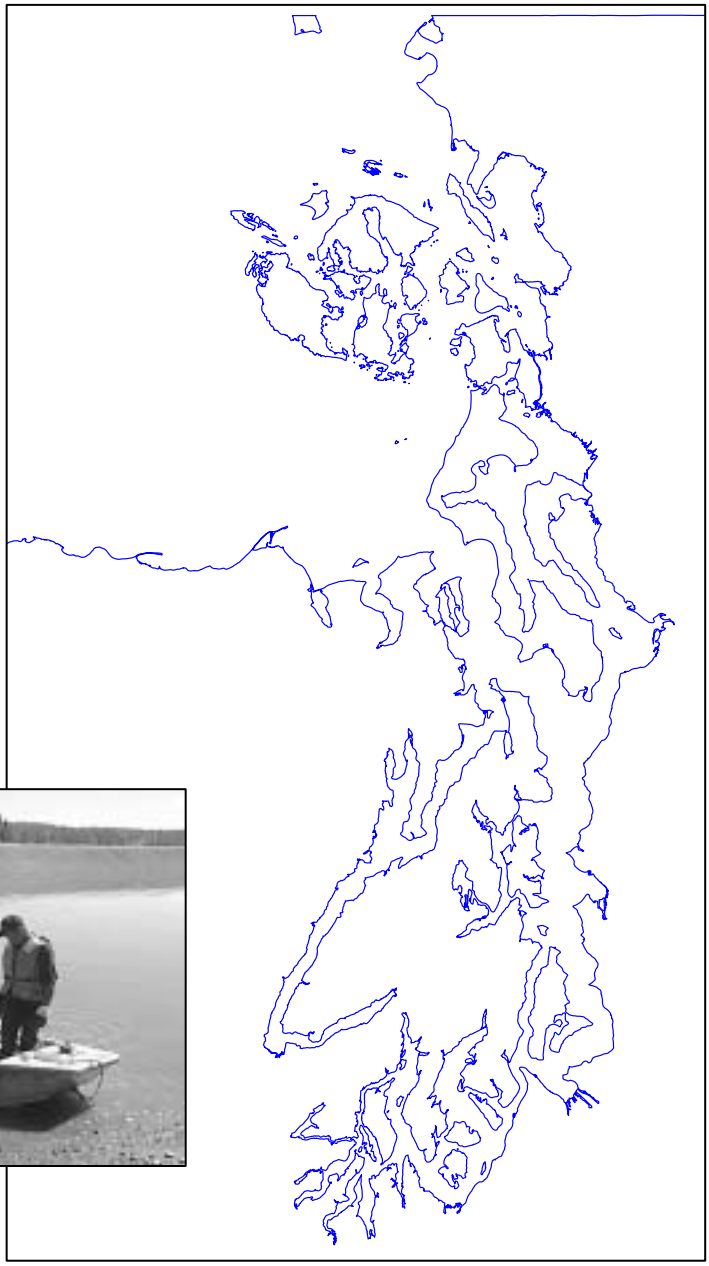
Atlas of Fecal Coliform Pollution in Puget Sound: Year 2001

A Report for the Puget Sound Ambient Monitoring Program



Washington State Department of Health

Office of Food Safety and Shellfish Programs

Atlas of Fecal Coliform Pollution in Puget Sound: Year 2001

A Report for the Puget Sound Ambient Monitoring Program

Tim Determan
Washington State Department of Health
Office of Food Safety and Shellfish Programs

January 2003

Washington State Department of Health

The Department of Health works to protect and improve the health of people in Washington State

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The reader may receive a copy of the technical supplement by contacting:

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Executive Summary

The mission of the Office of Food Safety and Shellfish Programs in the Washington State Department of Health (DOH) is to protect shellfish consumers from eating contaminated shellfish. A component of this mission is to monitor fecal pollution in over 100 commercial shellfish growing areas in Puget Sound, and the Straits of Georgia and Juan de Fuca. DOH also participates with other public agencies in the Puget Sound Ambient Monitoring Program (PSAMP). PSAMP is a comprehensive program to assess the health of Puget Sound. For PSAMP, DOH analyzed the status and trends of fecal pollution at 1197 sampling stations in 96 growing areas in Puget Sound, and the Straits of Georgia and Juan de Fuca through December 2001. These areas were ranked according to fecal pollution impact. Sampling stations within the ranked growing areas were examined for significant temporal trends.

Status in Calendar Year 2001

- Status was determined for 1197 sampling stations in 96 commercial shellfish growing areas in Puget Sound (see Figure 2 on page 9). Nearly 90% were GOOD. Four percent were FAIR and 5% were BAD.
- Sixty-five growing areas (68% of total growing areas examined) had stations that that were all GOOD.
- The remaining 31 growing areas had at least one station with a degree of fecal pollution (categorized as FAIR or BAD**)**. These areas were ranked according to fecal pollution impact (see Figure 3 on page 10). The growing area suffering the greatest fecal pollution impact this year was 1) Drayton Harbor (Strait of Georgia), 2) Henderson Inlet (South Puget Sound), and 3) Dungeness Bay (Strait of Juan de Fuca). Statistics were also tallied and categorized within regions of Washington's inland waters. The results were used to rank the regions in order of fecal pollution impact: 1) South Puget Sound, 2) Strait of Juan de Fuca, 3) North Puget Sound/Georgia Strait, 4) Admiralty Inlet/Main Puget Sound Basin, and 5) Hood Canal. The San Juan Islands showed the least impact.

Temporal Trends: All 1197 sampling stations were examined for temporal trends. About 10% of stations were getting worse. Another 10% improved, and 7.6% did not change. The rest of the stations were not examined for trends either because overall pollution was too low to warrant it, or the data record was too short.

Major Fecal Sources: Fecal coliform sources affecting all growing areas include failing on-site sewage systems and/or poor pasture management. Sources affecting Drayton Harbor, Henderson Inlet and Oakland Bay include contaminated urban stormwater and other assorted nonpoint sources. Drayton Harbor may also receive fecal wastes from boats. Portage Bay is affected primarily from dairy operations on the Nooksack River.

Individual Reports: An individual "focus sheet"-type report was prepared for each of 31 growing areas affected by fecal pollution (see Figure 2 for the location of each area). The reader may receive a copy of each individual report by phoning the author at (360) 236-3311 or by e-mail (tim.determan@doh.wa.gov).

Background

DOH Mandate: The Washington State Department of Health (DOH) classifies commercial shellfish growing areas and regularly monitors their condition to protect shellfish consumers from fecal pathogens, biotoxins, and contaminants. As of May 2001, DOH has classified nearly 200,000 acres of nearly 100 intertidal and subtidal commercial shellfish growing areas throughout Western Washington.

Puget Sound Ambient Monitoring Program: The Puget Sound Ambient Monitoring Program (PSAMP) is a multi-agency program coordinated by the Puget Sound Water Quality Action Team. PSAMP is a long-term comprehensive program that assesses the health of Puget Sound. DOH is a partner in PSAMP because of its extensive long-term monitoring activity. This report is an analysis of the status and trends of fecal coliform pollution at 1197 sampling stations in 96 shellfish growing areas in Puget Sound during 2001. DOH also produced a report on spatial and temporal patterns of the marine biotoxin (paralytic shellfish poison or PSP) in shellfish in Puget Sound (Determan 2003).

Why Monitor Fecal Coliform Bacteria? Scientists measure fecal coliform bacteria in the water to protect humans from contracting illnesses from pathogens (illness-causing microorganisms). Fecal coliforms are not generally pathogenic. Indeed, they are a normal part of the bacterial flora in the intestines of warm-blooded animals, including humans. When they are present, they indicate that fecal wastes have washed into the water. A significant number of fecal coliforms in the water mean that there is a risk of the presence of pathogens also. Shellfish pick up water-borne fecal pollution and concentrate it in their tissues as they filter their food out of the water.

Fecal Pollution Sources and Remedial Action: Since the early 1980s, nonpoint fecal pollution has become the key factor in closure of shellfish beds. Nonpoint sources include failed individual on-site sewage systems, poorly managed runoff from farms, sewage from boats, stormwater runoff and wildlife. Rapid migration of people into Puget Sound during the last three decades and the growing "suburbanization" of rural watersheds have increased the risk of pollution of shellfish habitat.

During the past decade, governments and citizens have dedicated time and resources to control pollution in most Puget Sound watersheds. Remedial action has included agricultural best management practices, repair of failed individual on-site sewage systems, upgrade of municipal sewage facilities, building of stormwater treatment facilities, and installation of boat-waste disposal stations at marinas and marine parks.

Classification of Shellfish Growing Waters: DOH applies guidelines set by the National Shellfish Sanitation Program (NSSP) in its classification program (NSSP 1999). The NSSP guidelines ensure thorough assessment of fecal pollution in shellfish harvest areas. Before an area is classified, DOH must collect 30 water samples from each sampling station in the growing area for fecal coliform bacteria. The samples must be collected under a variety of environmental conditions. In some cases, DOH has met this requirement in as short a time as a year, although longer times are usually needed.

Two statistics (a **geometric mean** and a **90th percentile***)* are calculated from the 30 water samples. These are compared to the **NSSP Growing Area Criteria**: The criteria and their application are described below:

1. The geometric mean is not to exceed 14 MPN/ 100 milliliters (ml) in water (applied in all cases).
2. The 90th percentile is not to exceed 43 MPN/100 ml of water (applied to areas where only nonpoint sources are present); OR ten percent of the results are not to exceed 43 MPN/100 ml of water (applied when one or more point sources of pollution are present).

(Notes: 1. MPN means "most probable number" and represents the concentration of fecal coliform bacteria. See Methods on page 5. 2. **Both** water quality criteria **must be met** in order to meet NSSP requirements.)

While data are collected, the upland watershed and the marine shoreline are carefully surveyed to find and assess pollution sources. An area cannot be approved for harvest if the survey reveals significant pollution threats, even if water quality is good. An area is classified **Approved** if water quality criteria are met **and** significant pollutant sources are absent. An area may be classified as **Conditionally Approved** if the pollution that occurs is *episodic* and *predictable*, such as rain-related runoff. (A detailed description is in Appendix A of the Technical Supplement). An area is classified **Restricted** if it is subjected to *limited*, and *unpredictable* pollution. If an area receives pollution that is chronically excessive and/or unpredictable, it is classified **Prohibited**. After classification, monitoring continues and shoreline surveys are periodically conducted to detect and evaluate changes.

DOH Early Warning System: Each year, DOH issues an "Early Warning" report to government and private interests if a growing area meets the following guidelines:

- **Threatened With a Downgrade:** 90th percentile at one or more stations equals or exceeds 30 MPN per 100 ml of water.
- **Identified Concerns:** 90th percentile at one or more stations equals or exceeds 20 MPN per 100 ml of water or 10 MPN if accompanied by worsening trend.

The 90th percentile is used to identify **Threatened** areas because 90th percentiles respond more quickly to changes in pollution than geometric means do.

Although analyses for PSAMP and Early Warning are similar, they were designed independently to meet different goals. The PSAMP analysis (described in this report) detects long-term change. The Early Warning analysis detects recent degradation of water quality to help prevent downgrades.

Methods

Field and Laboratory Protocols: DOH uses a systematic random sampling (SRS) strategy (NSSP 1999; see **References**) when sampling fixed stations in shellfish growing areas. There are over 1000 stations in nearly 100 growing areas throughout Puget Sound. The locations of growing areas are shown in Figure 2. The locations of sampling stations are shown in focused reports of selected growing areas later in this report. At least six samples per year are taken in **Approved** and some **Restricted** growing areas, and up to 12 samples per year in **Conditionally Approved** areas. Sampling runs are scheduled in advance to avoid bias from specific weather events, but evenly spaced throughout the year to allow seasonal variations to be examined.

Samples for fecal coliform analysis were collected according to APHA (1999). A 100ml sterilized polyethylene bottle was placed on the end of a 4-foot wand and swept into the current just beneath the surface of the water. At the same time, surface salinity, temperature, tide state and weather conditions are recorded. The samples are packed on ice and sent to the DOH Public Health Laboratory in Shoreline (north of Seattle). Although APHA (1999) specified a maximum holding time of 8 hours, DOH analyses were begun within 30 hours of collection due to travel time from remote areas (PSEP 1996). Fecal coliform bacteria are analyzed with the multiple tube fermentation (MPN) procedure using A-1 broth (Method 9221 E *in* APHA 1999).

Calculations: For PSAMP, DOH selected stations with relatively uninterrupted sampling history in each growing area. The earliest date was found such that there were 30 available results (one for that date and 29 previous results). Two statistics (a geometric mean and a 90^{th} percentile) were calculated from results 1 through 30. Statistics for the next date were calculated from results 2 through 31, etc., for all dates through December 2001 (Excel 5.0, Microsoft Corp.). The statistics were exported to STATISTICA 5.5 (Statsoft, Inc., Tulsa, OK) for statistical and graphical analysis.

PSAMP Versus Growing Area Classification: A careful reader may note that in some growing areas, graphs of some stations show that NSSP criteria are exceeded although the area is classified **Conditionally Approved** for harvest (for example, see Henderson Inlet, Figure 2c-e, page 44). An explanation of this seeming contradiction lies in understanding that DOH uses the NSSP statistics for two very different activities: 1) classification of growing areas and 2) PSAMP reporting. Both activities use the initially calculated statistics (described earlier). PSAMP uses them without further refinement to assess status and trends. For classifying growing areas, if the initial statistics comply with the NSSP criteria (and a shoreline survey uncovers no pollution impacts), DOH classifies the area **Approved**. If the initial statistics do not meet the **Approved** area criteria, DOH analyzes the data further to discover whether pollution factors can be predicted. If they are predictable, DOH writes a harvest management plan that defines conditions under which the **Approved** criteria will be met and classifies the area as **Conditionally Approved**. The most common **Conditionally Approved** classification is based on rainfall. For example, the **Conditionally Approved** part of Henderson Inlet is open except for a five-day closure period following a 24-hour rainfall total of 0.50 inch

or more. Thus, graphs for the **Conditionally Approved** part of Henderson Inlet may show that the 90th percentiles are above the NSSP criterion, yet the area is open to harvest under managed conditions.

Growing Area Status: The status of each growing area for calendar year 2001 was determined by sorting all 90th percentiles from all stations for all sampling dates during the year into three categories: **GOOD**, **FAIR**, or **BAD**. Each category is defined as follows:

- A 90th percentile was **GOOD** if it did not exceed the Early Warning threshold of 30 MPN per 100ml(See **DOH Early Warning System** Program on page 2).
- A 90**th** percentile was **FAIR** if it was more than the Early Warning threshold, but did not exceed the NSSP closure criterion of 43 MPN per 100ml.
- A 90**th** percentile was scored **BAD** if it was greater than the NSSP closure criterion of 43 MPN per 100ml.

For example, in calendar year 2001, 143 90th percentiles were calculated for Dungeness Bay (13 stations, 11 sampling dates). Sixty-one 90th percentiles (43%) were categorized as **GOOD**, 35 **(**24%) were **FAIR**, and 47 (33%) were **BAD** (See Appendices B and D in Technical Supplement). A pie chart showing percentages was placed on a map of Puget Sound and the Straits of Georgia and Juan de Fuca as a way to visually compare its status with the other 95 growing areas analyzed for PSAMP (Figure 2 on page 9).

Fecal Pollution Index: A **Fecal Pollution Index** (FPI) was calculated as a tool for ranking impact of fecal pollution in 2001. The FPI was applied at the level of a) sampling station, b) the growing area, and 3) regions within Puget Sound and the straits of Georgia and Juan de Fuca.

a) Sampling Stations: For each sampling station, the proportion of 90th percentiles within each category was multiplied by a corresponding weighting factor (**GOOD**: 1.0; **FAIR**: 2.0; or **BAD**: 3.0). Next, the resulting weighted proportional values were added to produce the FPI. If all 90th percentiles are **GOOD**, the index is 1.0 (100% × 1.0). On the other hand an index of 3.0 means all stations are **BAD** (100% × 3.0). A station with a mixture of categories would fall between the extremes. **Note: All stations with continuous records were evaluated in this way regardless of the classification (Approved, Conditionally Approved, etc.) of the portion of the area in which they were located.**

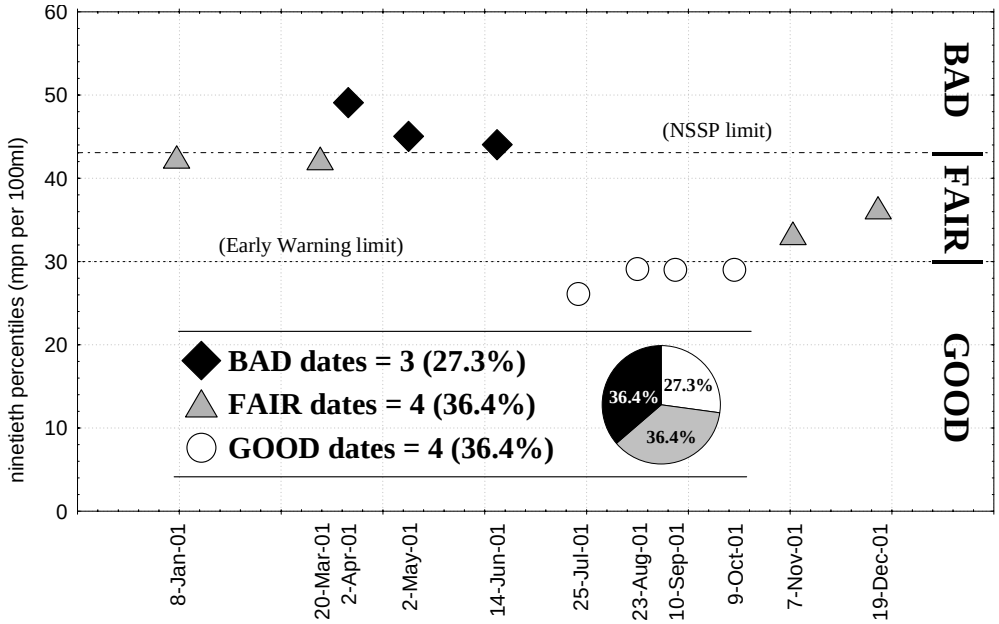
b) Growing Areas: To determine the FPI for each growing area, the number of 90th percentiles in each category was added over all stations in the growing area. Proportions were then determined, weighted, and added, as described above. The results were used to rank growing areas according to FPI (see Figure 3 on page 10).

c) Puget Sound Regions: An FPI was also calculated for each of five regions in Puget Sound (North Puget Sound/Georgia Strait, San Juan Islands, the Strait of Juan de Fuca, Admiralty Inlet/Main Basin, Hood Canal, and South Puget Sound). Regional FPIs were calculated by summing the number of 90th percentiles in each category over all stations in

all growing areas of each region. Finally, a Sound-wide index was determined by adding the number of 90th percentiles in each category from all stations in all growing areas in Puget Sound and the Straits of Georgia and Juan de Fuca.

Station Status: To provide a visual image of the status of an individual station in calendar year 2001, the 90th percentile calculated for each sampling date in 2001 was plotted according its respective sampling date in 2001 (Figure 1). (See **Calculations** in **Methods** on page 5.) The 90th percentiles were sorted into the three groups: **GOOD**, **FAIR**, and **BAD** (defined on page 5). Then a pie chart was generated for each station that could be compared visually to others on a map of the growing area.

Figure 1. Determining Station Status Using a Plot of 90th Percentiles Versus Date (Station 109 Dungeness Bay)



Station Trends: The period of record for many growing areas extends back for over a decade. However, in order to detect only recent trends, the time period for this year's PSAMP trend analysis was limited to five years (1 January 1997 through 31 December 2001). Seventy-two percent of all stations routinely sampled by DOH were rejected for trends work because; 1) the fecal pollution was so low (i.e., 90th percentiles of 10 MPN per 100 ml or less) that their trends were uncertain (and of little interest), or 2) a length of record less than three years.

Trends were determined on the remaining 341 (28%) of 1197 stations. Geometric means and 90th percentiles were graphed against sampling dates. Spearman's *rho*, a nonparametric statistical test for trends based on ranks (STATISTICA, Statsoft, Inc., Sokal and Rohlf, 1969) was used to confirm visual evidence of temporal trend in 90th percentiles. The trend at individual stations (based on Spearman's *rho*) was shown by appropriate symbols on a map of the growing area. The map and selected graphs were

included in a 2-page "focus sheet"-type report later in this report. The reader may receive a "focus sheet" report by calling the author at (360) 236-3311 or by e-mail (tim.determan@doh.wa.gov).

Results (Puget Sound-Wide)

Status of Growing Areas: The status of fecal pollution in 96 growing areas examined in calendar year 2001 is summarized as pie charts in Figure 2. (Note: Ninety-five areas are listed in Figure 2 because Mystery and Scow Bays are combined into one pie chart to conserve space.) Areas that are "impacted" by fecal pollution had at least one station that was categorized as either **FAIR** or **BAD**. These are listed in **BOLD** type on Figure 2. Major growing areas with the greatest fecal pollution impact appear to be Drayton Harbor, Dungeness Bay, and Henderson Inlet.

Ranking of Status by Fecal Pollution Index

a. Growing Areas: Sixty-five of 96 growing areas (68%) had fecal pollution indices of 1.0 (i.e., all stations in the growing area were **GOOD**). The remaining 31 areas (32%) were ranked according to FPIs in Figure 3. Nonpoint pollution sources in all areas may include failing on-site sewage systems and upland pasture drainage. Sources in Drayton Harbor and Henderson Inlet include contaminated urban stormwater among other nonpoint sources. Drayton Harbor may also receive fecal wastes from boats and wildlife. Oakland Bay sources include overflowing sewer lines during heavy rainfall. Major fecal pollution into Portage Bay likely comes from dairies along the Nooksack River.

b. Regions: South Puget Sound suffered the greatest fecal pollution impact (FPI=1.24). Next comes the Strait of Juan de Fuca (FPI = 1.18) due mainly to conditions in Dungeness Bay. Then comes North Puget Sound/Georgia Strait (FPI =1.14). Admiralty Inlet and Main Basin (FPI =1.10), and Hood Canal (FPI = 1.06) showed intermediate impact. The San Juan Islands showed the least impact (FPI=1.0).

Summary: Status was determined for 1197 stations in 96 growing areas examined (Appendices B and E). Nearly 90% of statistics were **GOOD**. Four percent of statistics were **FAIR** and 5% were **BAD**. About 10% of the stations got worse. Another 10% improved and 7.6% had not changed significantly. The remaining 72% of stations were not examined for trends because they did not meet the criteria for doing trends (see **Station Trends** on page 7).

Figure 2. Status of Fecal Coliform Pollution in Shellfish Growing Areas Throughout Puget Sound And The Strait of Juan de Fuca

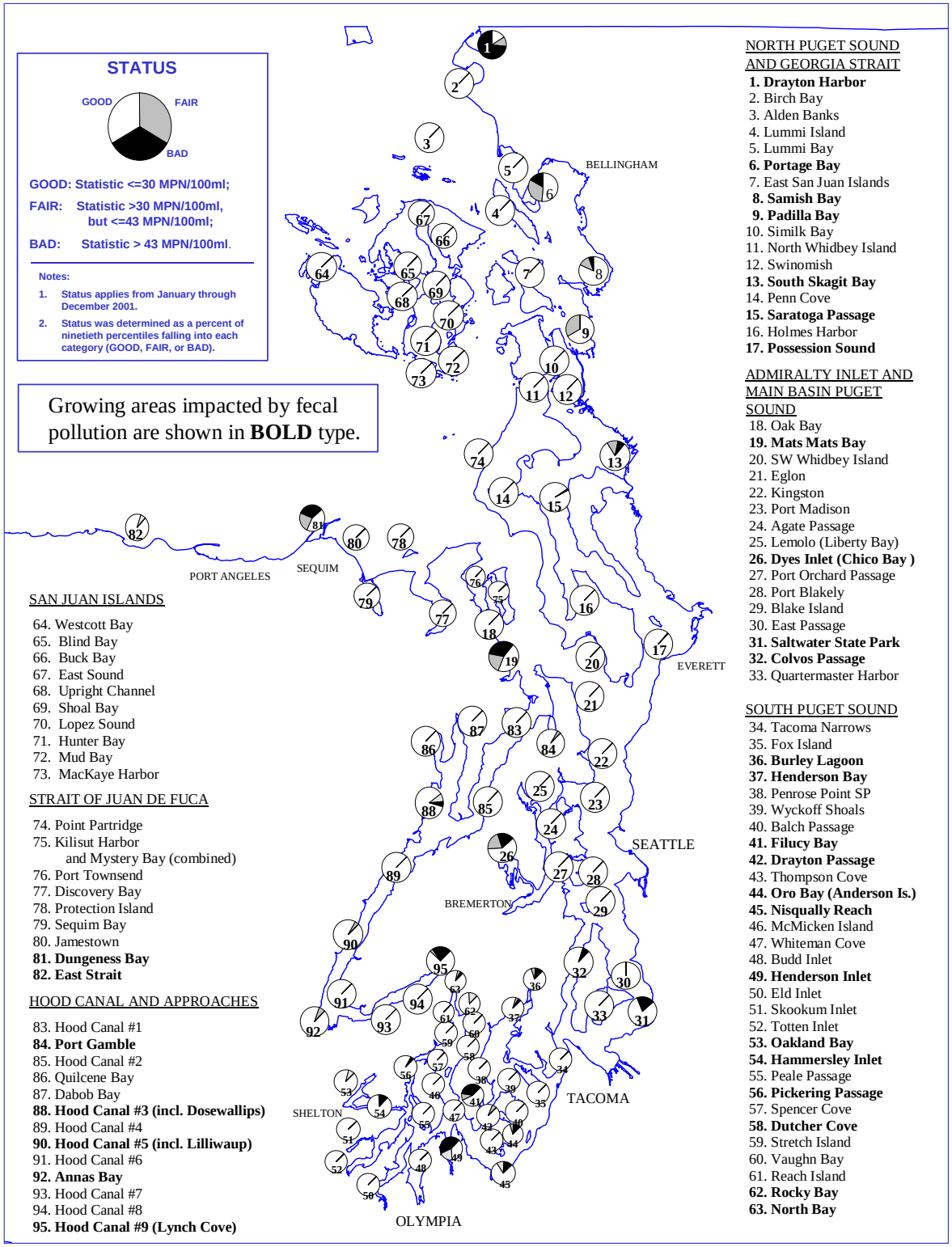
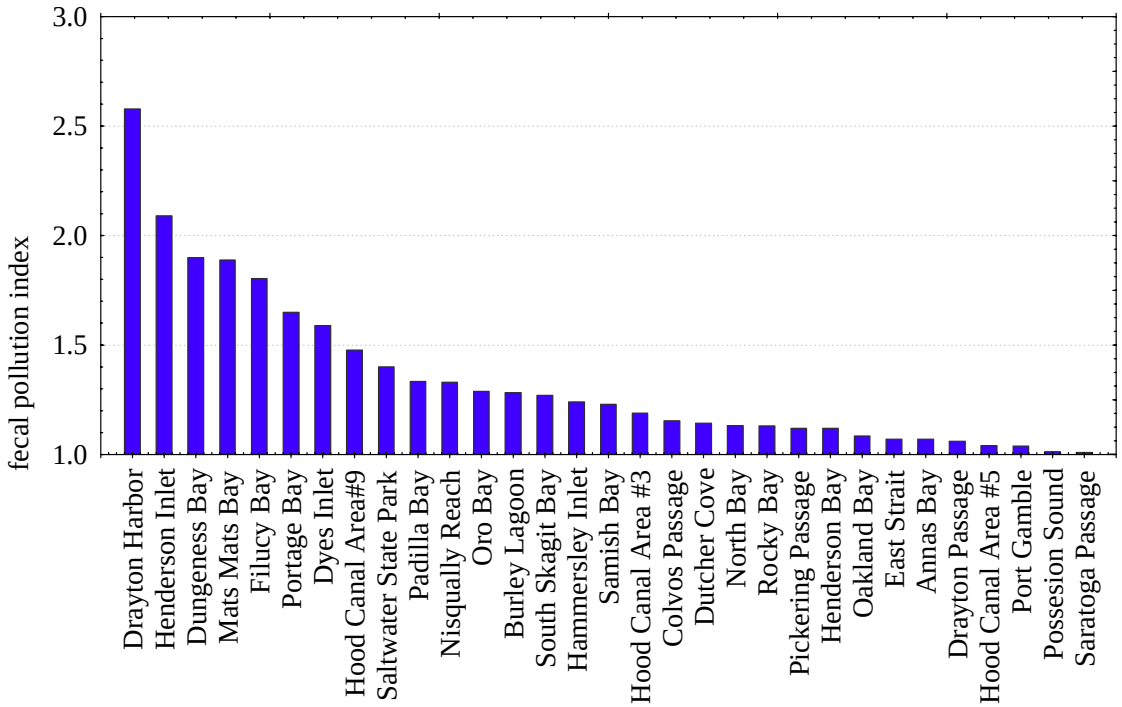


Figure 3. Ranking of Shellfish Growing Areas According to Fecal Pollution Impact



Summaries For Individual Growing Areas

The remaining sections of this report (pp 11-72) are individual summaries for the 31 shellfish growing areas listed in **bold** in Figure 2. The reports are ordered according to the order shown on Figure 2. The individual summaries are designed as stand-alone "fact sheets that may be copied and distributed as needed. Each fact sheet contains a map of the growing area (Figure 1) showing status (as pie charts) in calendar year 2001 and trends (appropriate symbols) during the 3-5 year period before 31 December 2001. Figure 2 of each fact sheet has graphs of statistics (geometric means and 90th percentiles) over time for selected stations of interest. Early Warning stations (see page 2) are indicated by **EW** on the map and noted also on individual graphs.

Tabulated summaries for each growing area analyzed in calendar year 2001 are in the Technical Supplement available upon request (see Page ii):

- Appendix B lists the classification(s) of each growing area and status (as categorized results and FPIs) for each sampling station in every growing area.
- Appendix C summarizes results of statistical tests for trends for each sampling station in every growing area.
- Appendix D lists impact indices for each growing area.
- Appendix E provides summarizes status (as FPIs) and trends for regions within Puget Sound and the Straits of Georgia and Juan de Fuca.

Whatcom County

Drayton Harbor

Background: In early 1995, the Washington State Department of Health (DOH) downgraded over 1000 acres of growing area in Drayton Harbor from **Approved** to **Prohibited**. Local interests and agencies have conducted remedial action programs, including repair of on-site sewage systems, planning and installation of agricultural best management practices, improved boat waste handling at the two local marinas, and improvements in Blaine's sewer collection system. These actions did not improve water quality. In 1999, DOH downgraded all of Drayton Harbor to **Prohibited**.

Status and Trends: Five of 7 stations in Drayton Harbor were in the **BAD** category on each sampling date during 2001 (Figure DRT-1). Station 5 at mid-bay ("c" in Figure DRT-1) was in the **GOOD** category on each sampling date. Two stations became increasingly polluted. Two more improved and three remained unchanged. Figure DRT-2 shows graphs for all stations in Drayton Harbor. The greatest pollution occurred at stations 8 and 15 ("e" and "g" in Figure DRT-1) near the Port of Bellingham Marina. Fecal pollution statistics jumped markedly in 1999 and then dropped at most stations (Figures DRT-2a-f). However, pollution increased continuously at Station 15 since 1999.

Figure DRT-1. Status and Trends of Fecal Pollution in Drayton Harbor Through December 2001

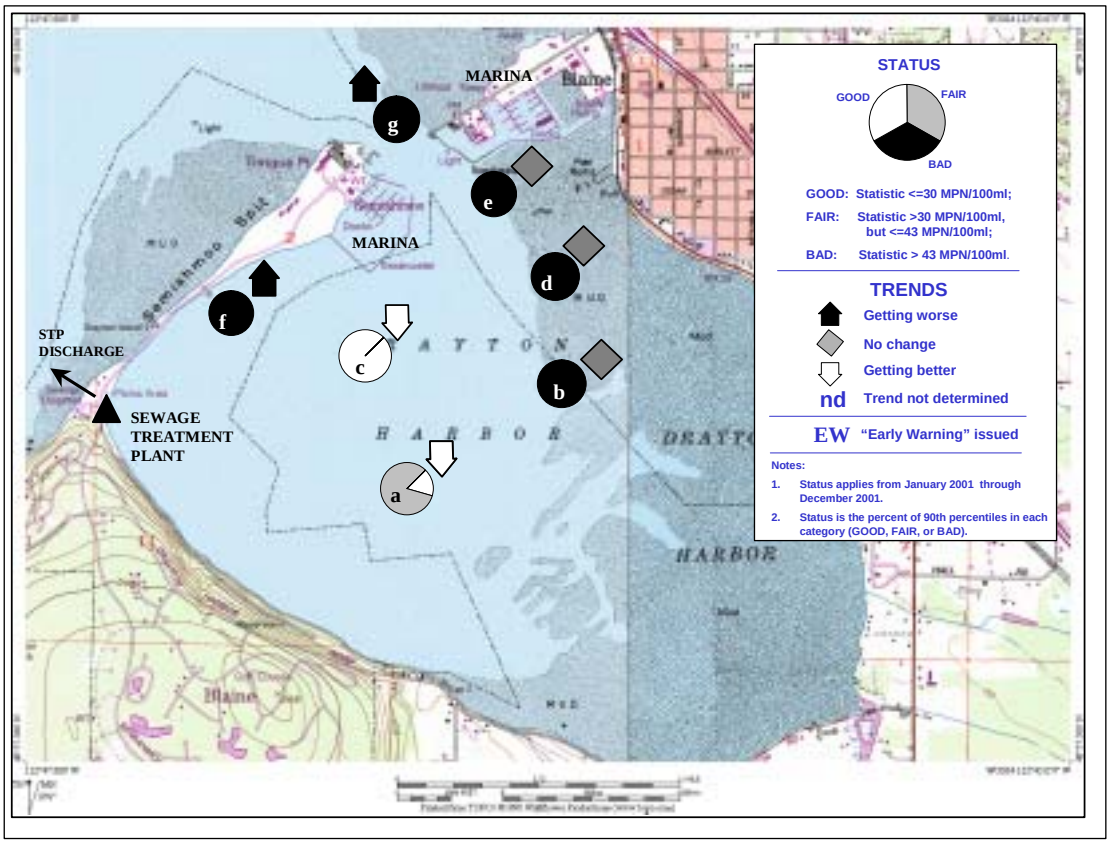
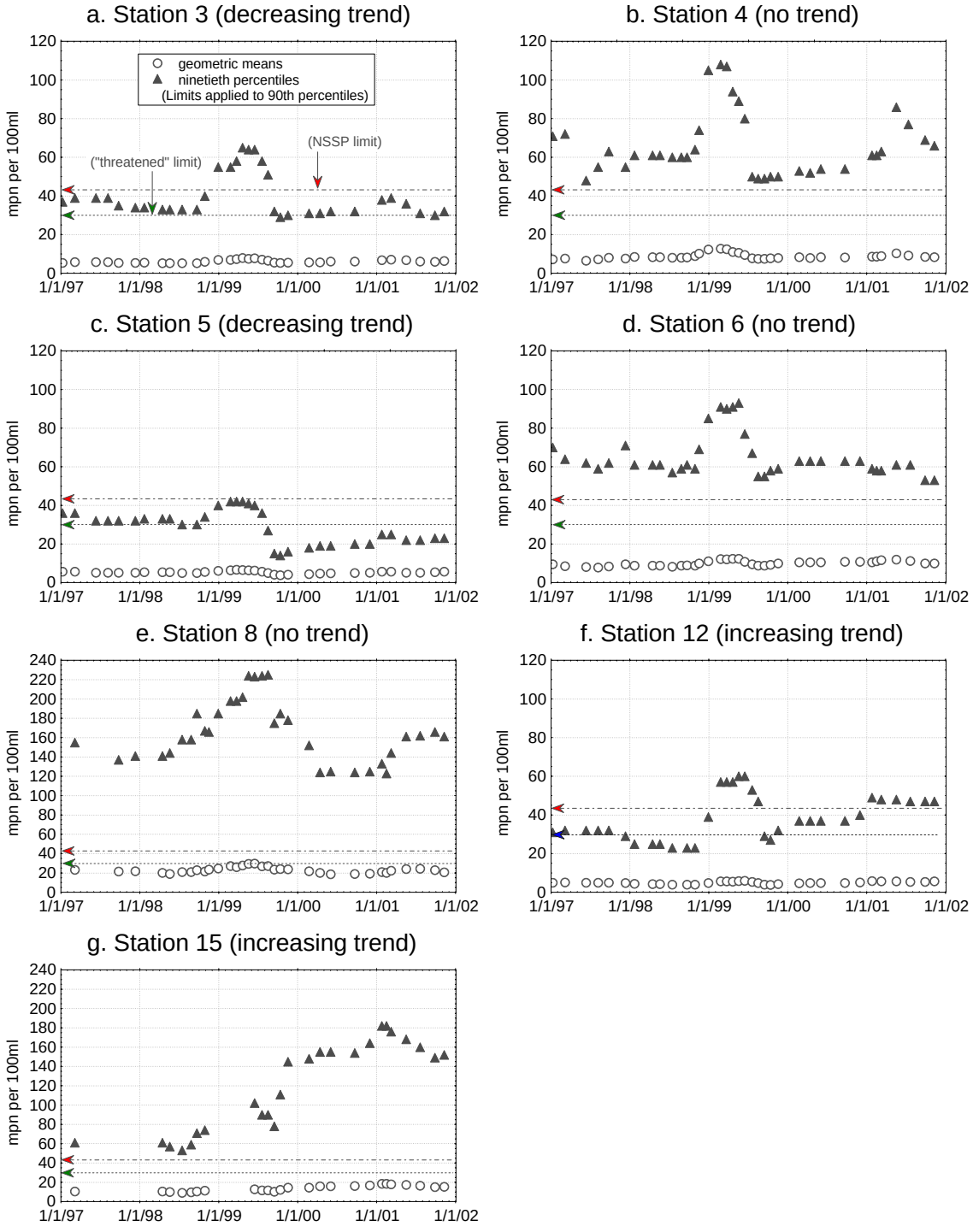


Figure DRT-2. Fecal Pollution Over Time in Drayton Harbor



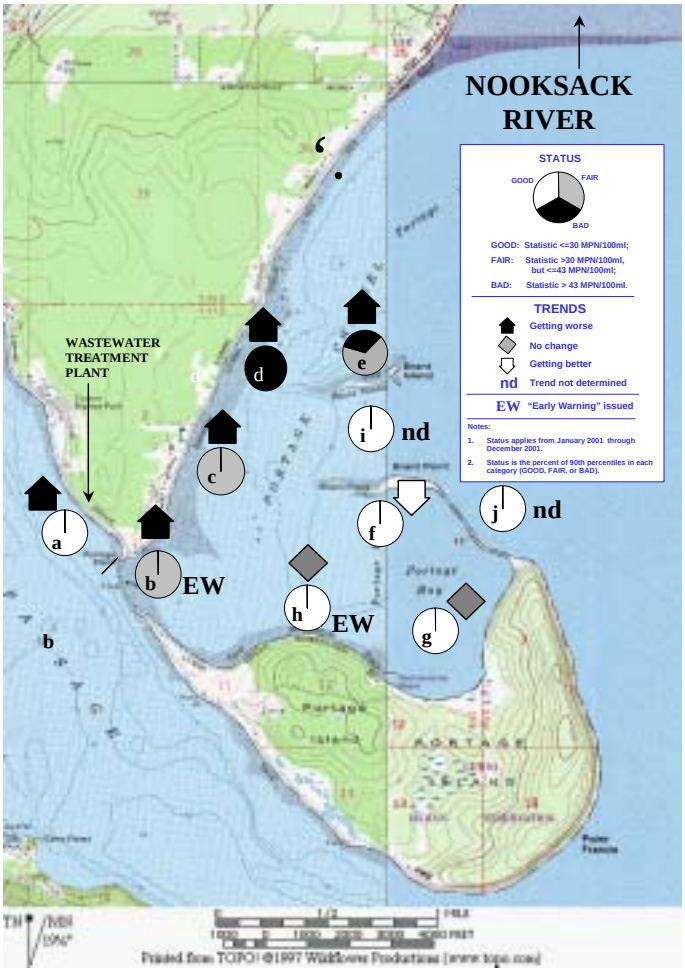
(Note: Trends were tested for statistical significance with Spearman's R.)

Whatcom County

Portage Bay

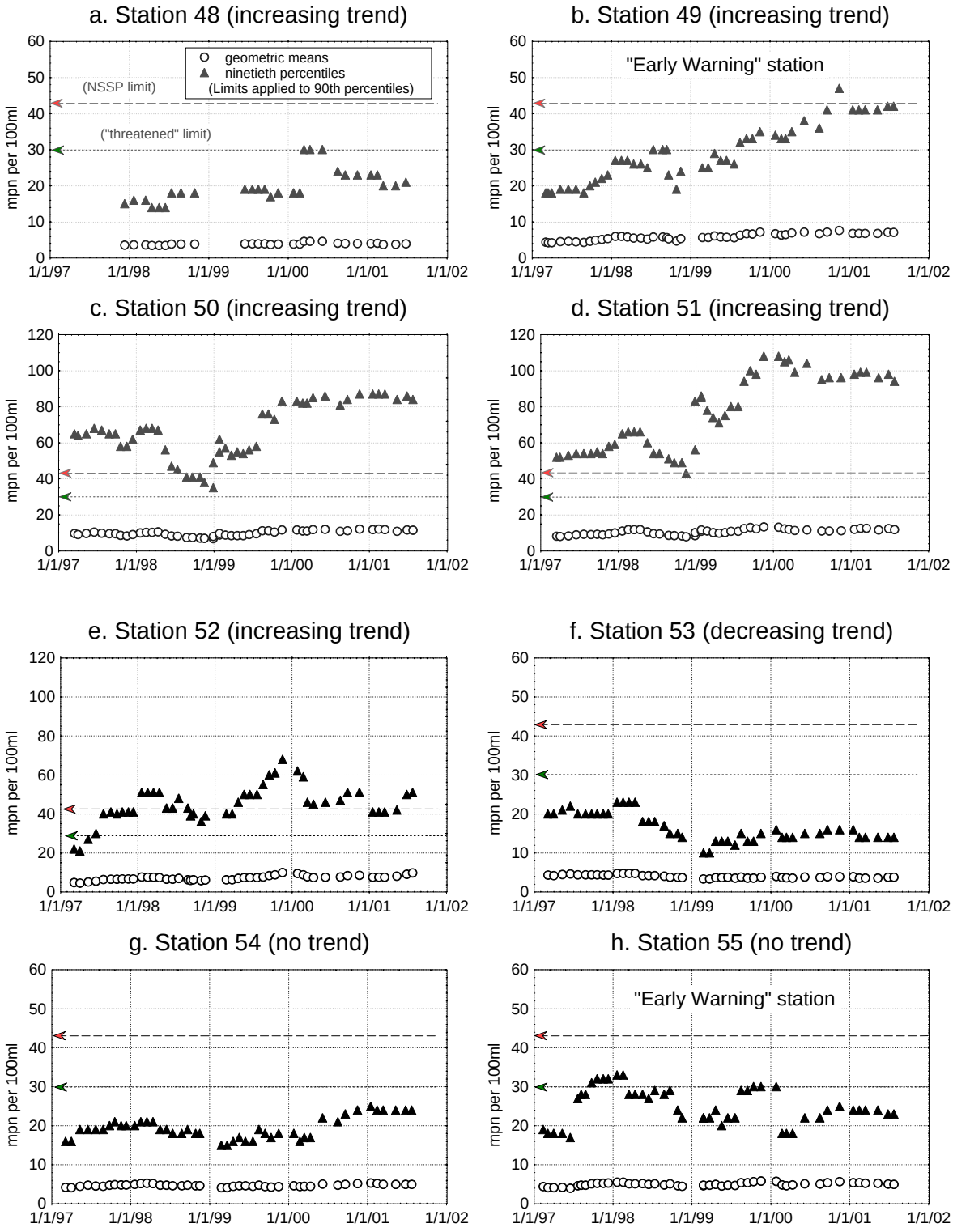
Background: The Lummi Nation, the traditional shellfish harvester in Portage Bay, voluntarily ceased harvest in late 1996 due to increasing fecal pollution. The Washington State Department of Health (DOH) downgraded north Portage Bay to **Restricted** by mid-August 1997. Dairies along the lower Nooksack River were identified as the principal fecal source. U.S. EPA Region 10 and the Washington State Department of Ecology (Ecology) brought legal action against some dairies for direct discharge of manure into the Nooksack River. A "total maximum daily load" (TMDL) study by Ecology proposed numerical limits on fecal coliform sources. Several dairies implemented dairy nutrient management plans. Recent water current studies done by DOH showed no effect from Gooseberry Wastewater Treatment Plant. DOH expanded the **Restricted** zone in the north in early 1999. The southern end of Portage Bay remains **Approved**.

Figure PRT-1. Status and Trends of Fecal Pollution in Portage Bay Through December 2001



Status and Trends: Five stations just north of Portage Island and Station 9 near the Gooseberry Point treatment plant were in the **GOOD** category on each sampling date in calendar year 2001 (Figure PRT-1, "a" and "f"-"j"). One station was **BAD** and two others were always **FAIR** during the year. Five stations showed a worsening trend, two showed improvement, and two more were unchanged. The pattern of impact suggested the Nooksack River is its major source. DOH listed two stations as **Threatened** in its Early Warning system. Figure PRT-2 shows graphs for selected stations.

Figure PRT-2. Fecal Pollution Over Time in Portage Bay



(Note: Trends were tested for statistical significance with Spearman's R.)

Skagit County

Samish Bay

Background: In August 1994, 25% of Samish Bay was downgraded to **Restricted** or **Prohibited**. Pollution sources included failed on-site sewage systems in Blanchard and elsewhere, raw sewage from Edison, and extensive pasture drainage. A new sewage treatment system was built in Edison and numerous on-site sewage systems were repaired in Blanchard. About three miles of stream bank were fenced. In June 1998, a third of the shellfish beds were upgraded. By July 2002, all remaining **Conditionally Approved** areas were upgraded to **Approved**. However, DOH listed stations 81 and 90 as **Threatened** in its Early Warning system ("t", "k" in Figure SMS-1).

Status and Trends: Seventeen of 24 stations were categorized as **GOOD** on each sampling date in 2001 (Figure SMS-1). Southwest Samish Bay was the most affected by fecal pollution. Six stations in this area had some **FAIR** sampling dates. Station 89 ("s" on Figure SMS-1) had some **BAD** dates. Station 83 at the mouth of Edison Slough ("m" on Figure SMS-1) had all **BAD** sampling dates. Figure SMS-2 shows graphs of fecal pollution at selected stations. Station 83 near Edison Slough has not improved, despite the new sewage system in Edison. Agricultural wastes discharged through tide gates into Edison Slough and onto the nearby shoreline may be the significant pollutant source now.

Figure SMS-1. Status and Trends of Fecal Pollution in Samish Bay Through December 2001

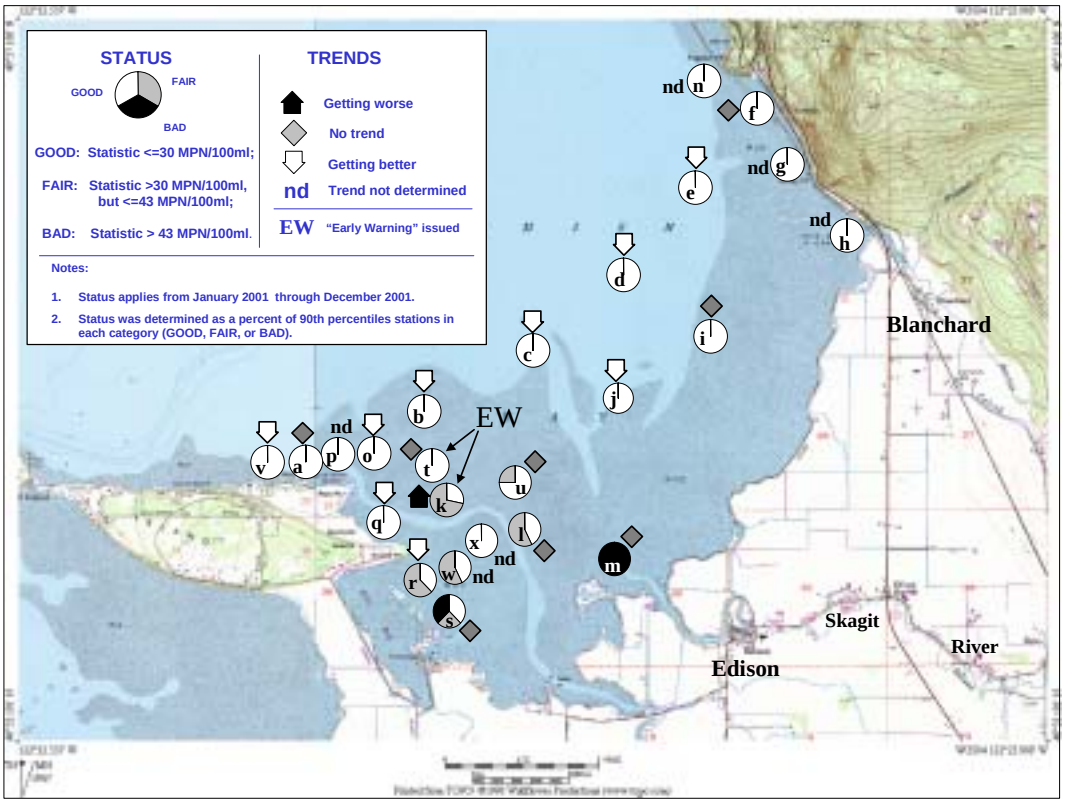
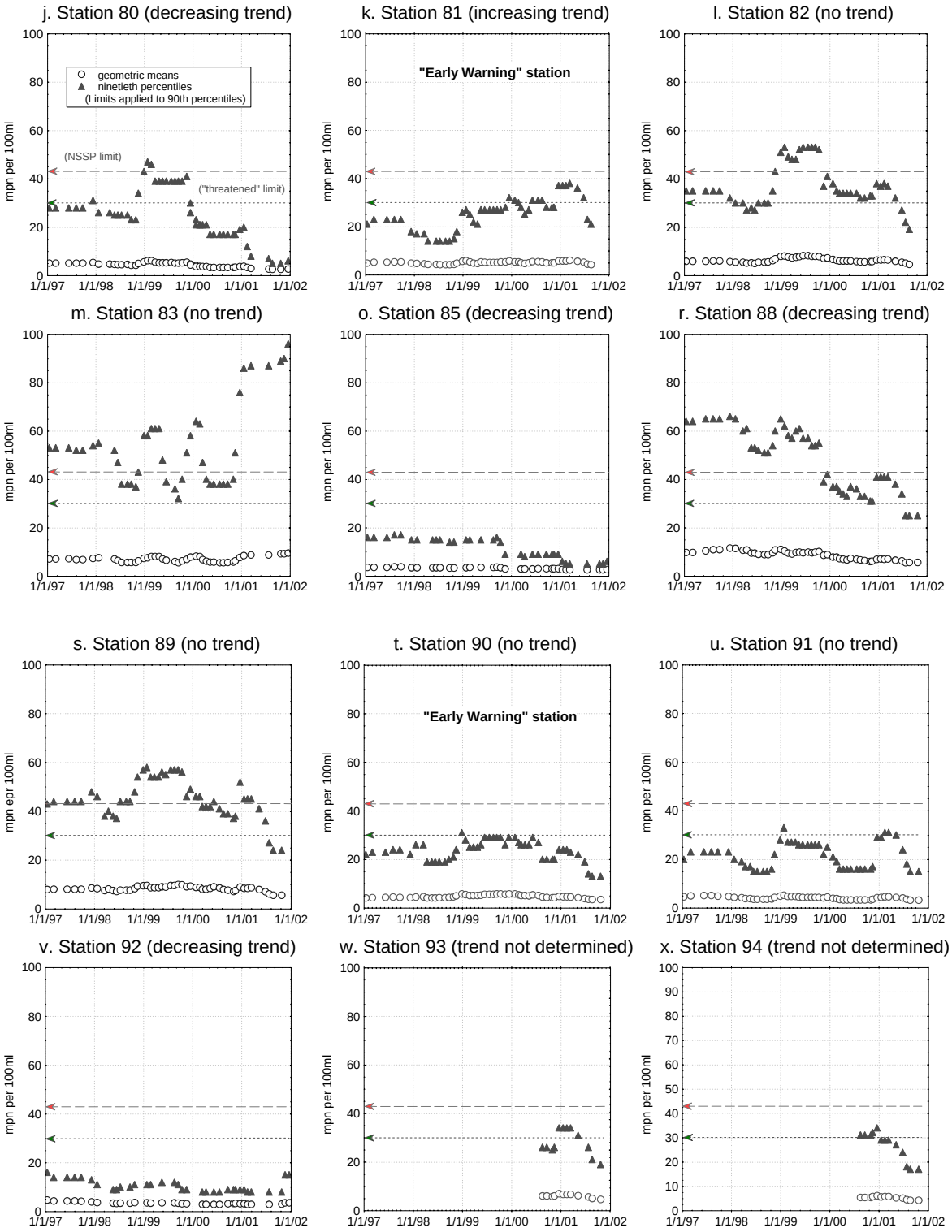


Figure SMS-2. Fecal Pollution Over Time in Samish Bay



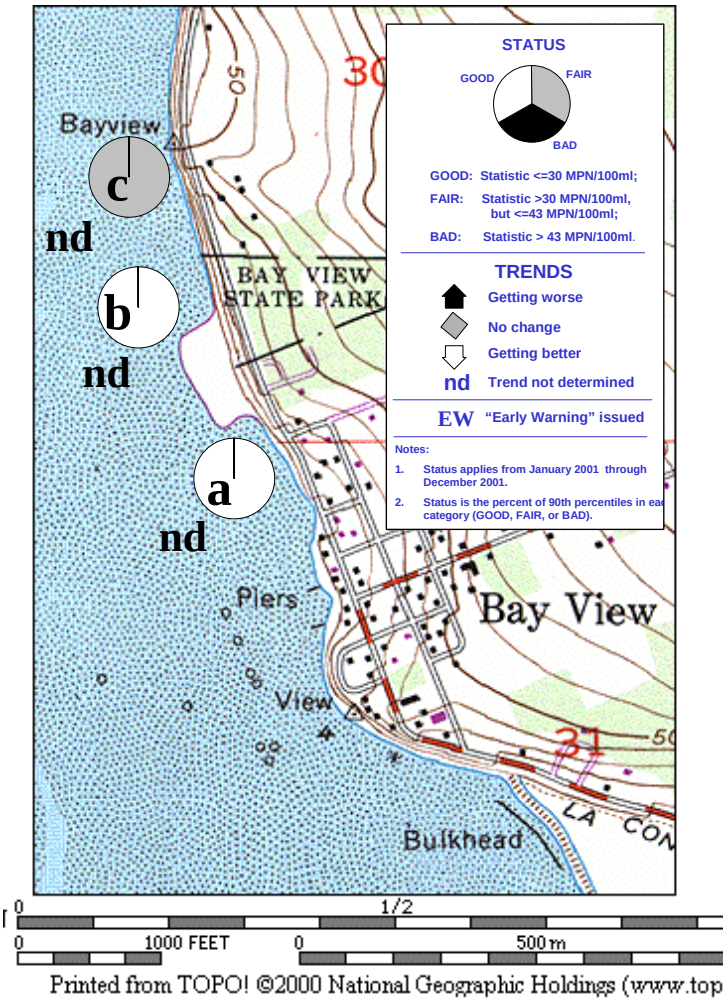
(Note: trends were tested for statistical significance with Spearman's R)

Skagit County

Padilla Bay

Background: In 1999 the Skagit System Cooperative (a consortium of treaty tribes) requested the Washington State Department of Health (DOH) to certify for harvest the tidelands at Bayview State Park. DOH began sampling of drainages along the shoreline and conducted a shoreline survey. They found significant potential for fecal pollution from on-site sewage systems and upland agricultural activities. Past and current studies by the Padilla Bay National Estuarine Research Reserve and the Skagit Stream Team indicated significant fecal pollution coming from nearby sloughs.

Figure PDA-1. Status of Fecal Pollution in Padilla Bay Through December 2001



Status and Trends: DOH started sampling three stations along the eastern shore of Padilla Bay near Bayview State Park (Figure PDA-1). Data collection began in February 2000. Consequently statistics are calculated with insufficient data to meet NSSP criteria (minimum of 30 samples). So the status shown here is based on a single statistic, and trend analysis was not done. Station 268 (‘”c” in Figure PDA-1) was **FAIR**. The others were **GOOD**.

Skagit and Snohomish Counties

South Skagit Bay

Background: Nearly 6000 acres of shellfish grounds in south Skagit Bay were downgraded from **Approved** to **Restricted** in March 1987 due to rural nonpoint pollution. Over 9000 acres in north Skagit Bay were downgraded in 1989. In 1993, Washington State Department of Health (DOH) upgraded over 2000 acres from **Restricted** to **Conditionally Approved** after improvements to the Stanwood Sewage Treatment Plant and control of agricultural sources along the Stillaguamish Slough. In 1996 a "total maximum daily load" (TMDL) study in the Lower Skagit River by the Washington State Department of Ecology proposed numerical limits on fecal coliform sources.

Status and Trends: Figure SSK-1 indicates that the greatest impact from fecal pollution occurred at stations located near the mouth of the south fork of the Skagit River. This fact suggests the Skagit River was the major source of fecal pollution. Figure SSK-2 suggests that statistics at most stations improved substantially in the past year, although the improvement could not be statistically confirmed.

Figure SSK-1. Status and Trends of Fecal Pollution in South Skagit Bay Through December 2001

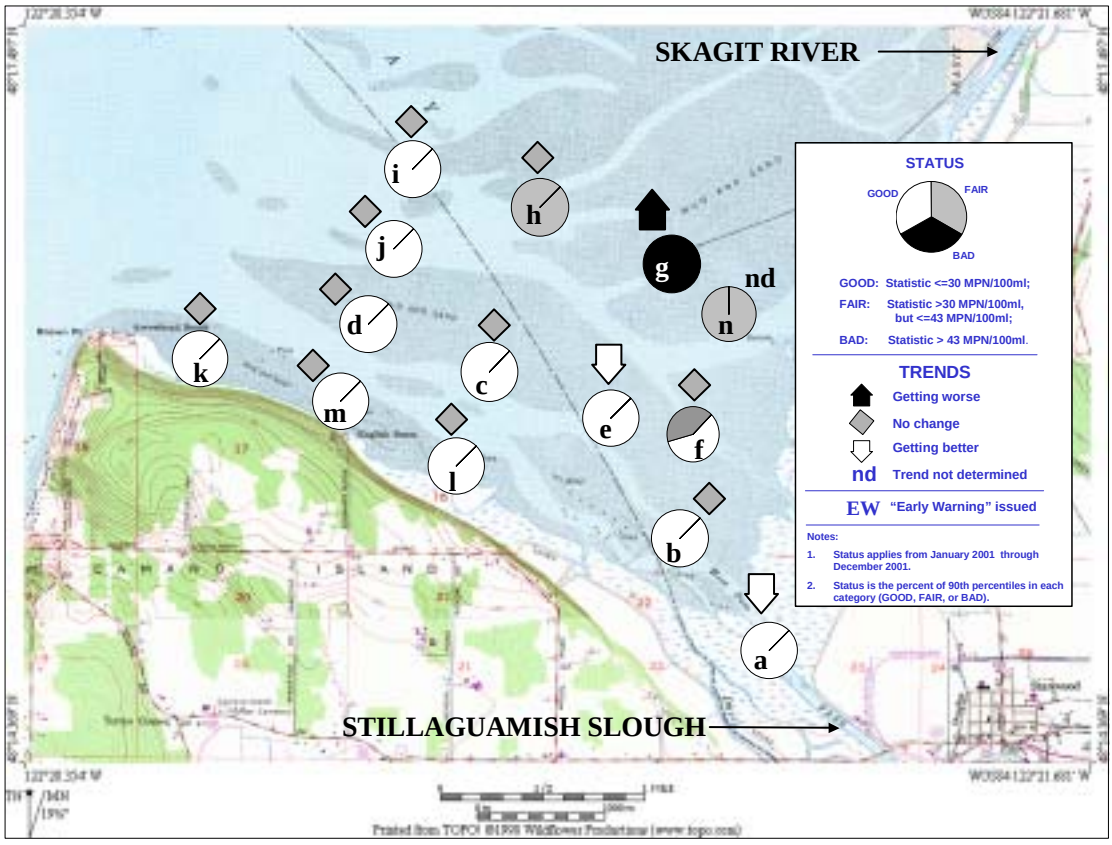
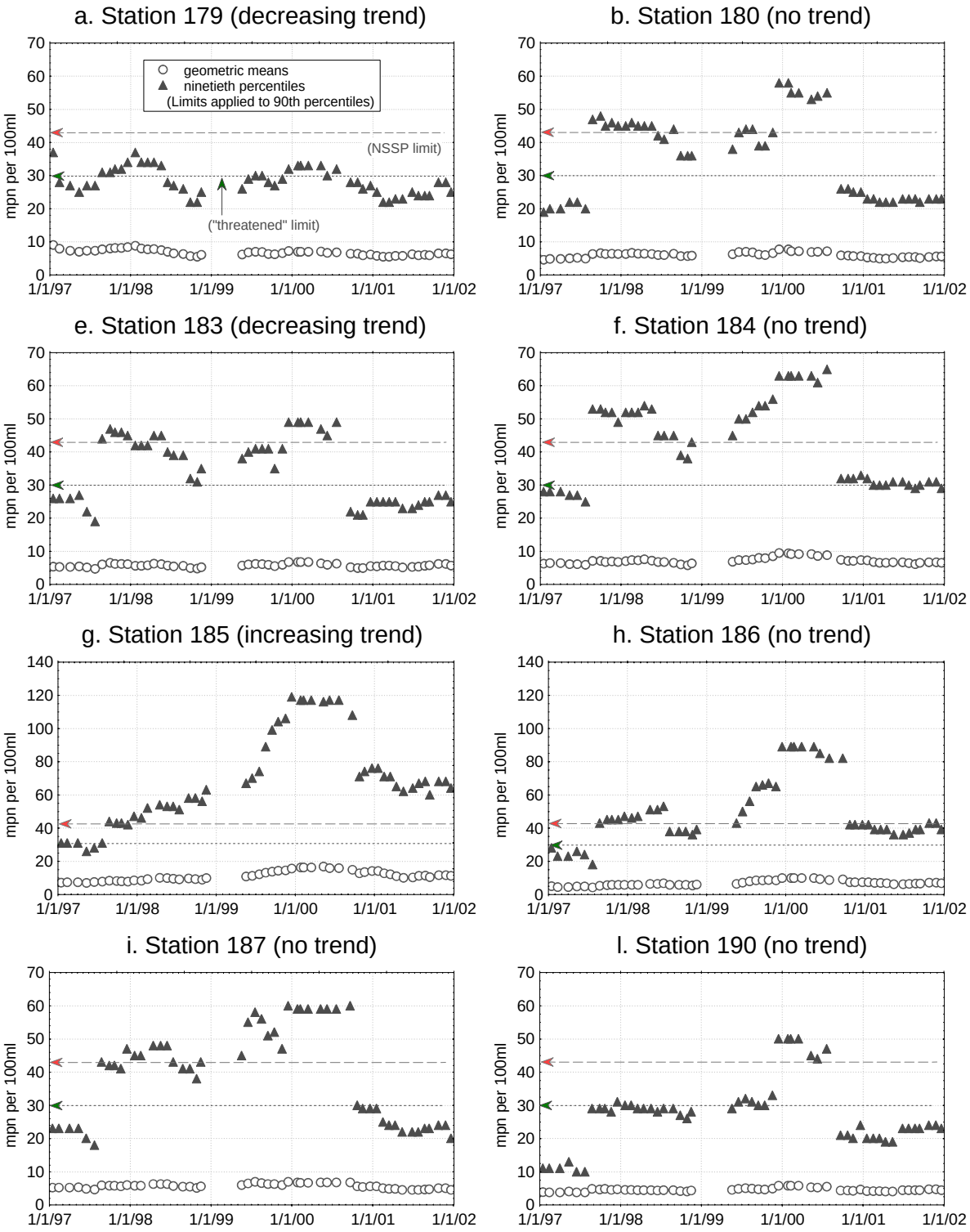


Figure SSK-2. Fecal Pollution Over Time in South Skagit Bay



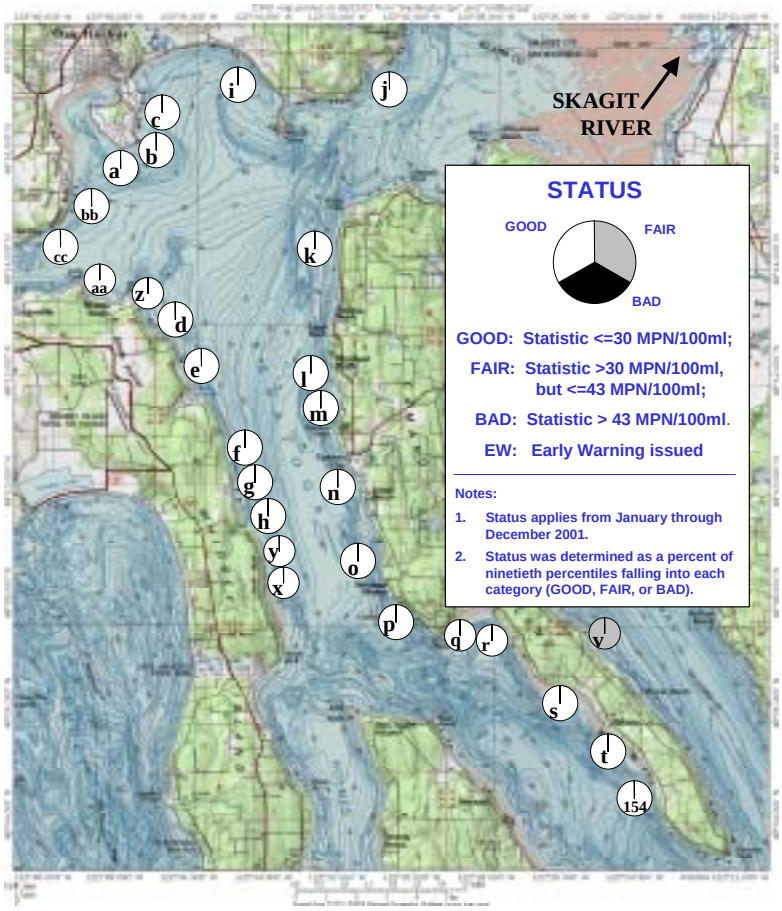
(Note: trends were tested for statistical significance with Spearman's R)

Island County

Saratoga Passage

Background: The Washington State Department of Health (DOH) completed a shoreline survey of Saratoga Passage in summer 1996 following a request by the Skagit System Cooperative to evaluate 9.4 shoreline miles of potentially harvestable shellfish grounds. DOH surveyed 76 on-site sewage systems along the marine shoreline. Fifteen systems along Harrington Lagoon and five in Race Lagoon within 50 feet of the shore were deemed "suspect" pollution sources. Industrial activity, a sewage treatment plant outfall, and limited boating activity were noted near Forbes Point. The public beach east of Forbes Point receives nearly 3,000 shellfish harvesters per year. No direct discharges or failed sewage systems were seen. Most of Saratoga Passage was classified **Approved** in May 2000. **Prohibited** zones were placed in Harrington Lagoon and around the sewage treatment plant discharge in Crescent Harbor. Race Lagoon was **Unclassified**.

Figure STG-1. Status of Fecal Pollution in Saratoga Passage Through December 2001



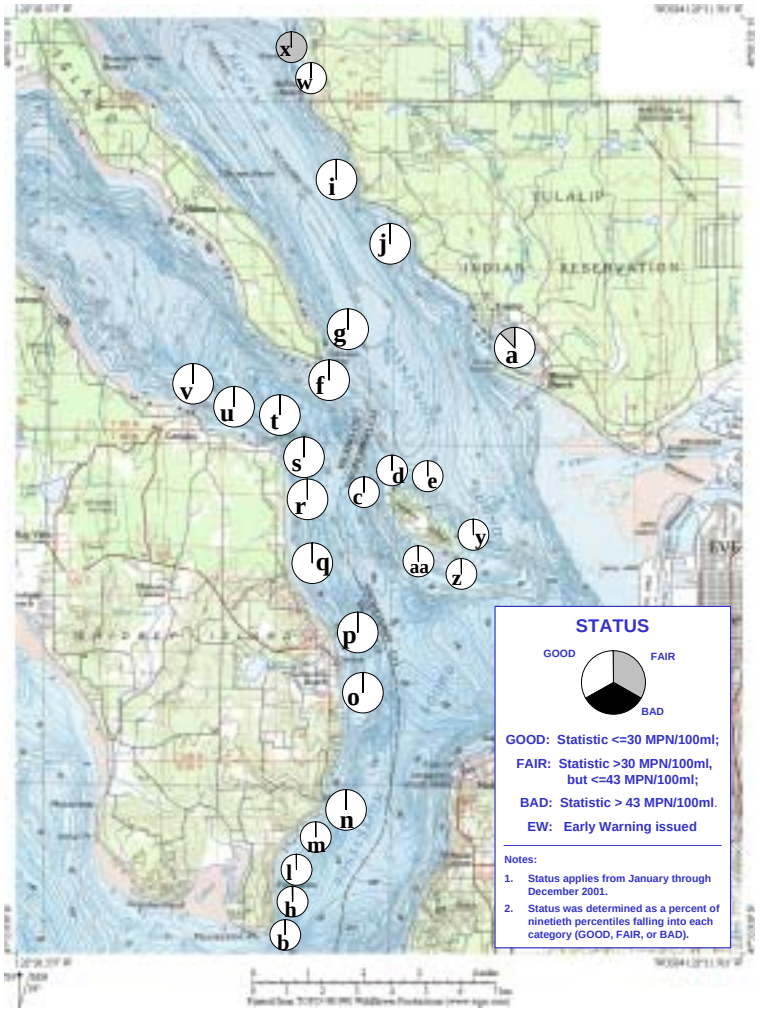
Status and Trends: Sampling of Harrington and Race lagoons ceased in September 2000. Station 155 in Port Susan on the east side of Camano Island ("v" on Figure STG-1) was **FAIR**, although its status is based on a single statistic. The status of the remaining stations was **GOOD**. Trends were not determined because the data record was too short. Fecal pollution was generally very low.

Island and Snohomish Counties

Possession Sound

Background: In 1996 the Washington State Department of Health (DOH) began sampling and conducting sanitary surveys in Possession Sound in response to requests from the Tulalip Tribe for certification for shellfish harvest of 22 miles of shoreline harvest. In October 2001 shoreline surveys were completed. Over 600 sources, 33 drainages, and two agricultural sites were examined. Unsatisfactory conditions were identified along at developments along southeast Gedney Island, near Randall Point (just north of Clinton on Whidbey Island), and North Tulalip (east shore of Port Susan). Portions of the shoreline in these areas were **Unclassified**. Two **Prohibited** zones were set at the Tulalip Sewage Treatment Plant (near Mission Beach) and the Hat Island Yacht Club Marina on the northeast shore of Gedney Island.

Figure PSS-1. Status of Fecal Pollution in Possession Sound Through December 2001



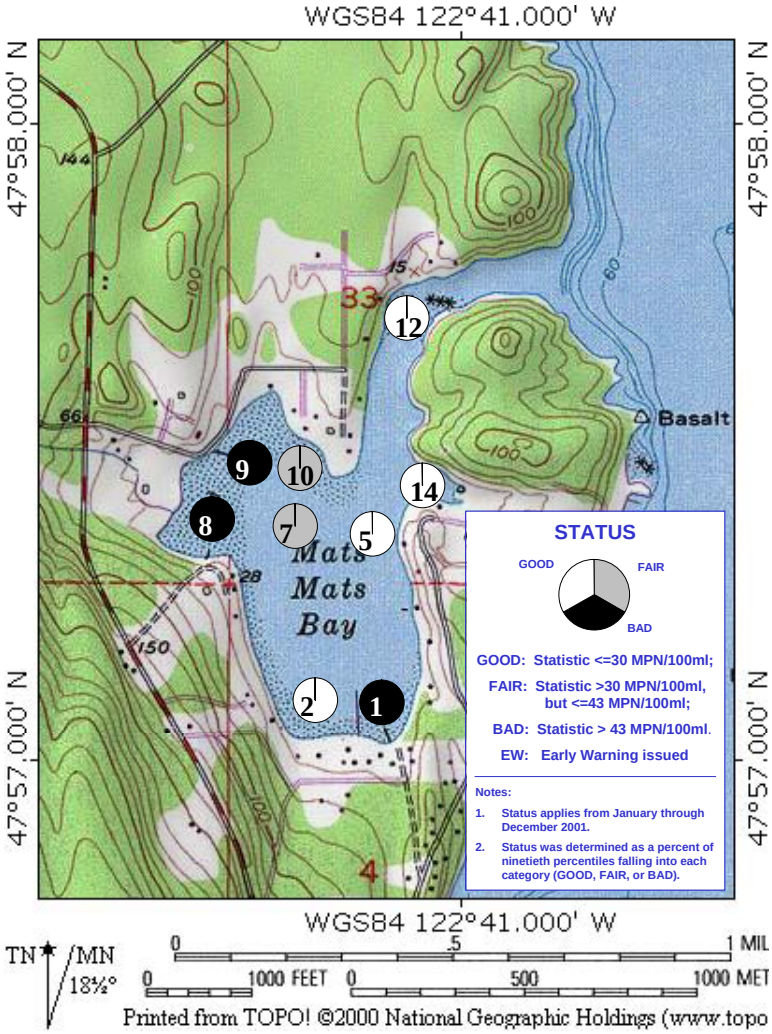
Status and Trends: Trends in Possession Sound were not determined due to short data record. Two stations in Port Susan were less than **GOOD** on some dates; Station 222 near Tulalip and Station 245 near Point McKee to the north ("a" and "x", respectively in Figure PSS-1).

Jefferson County

Mats Mats Bay

Background: In April 2001 the Washington State Department of Health (DOH) evaluated conditions along the shoreline of Mats Mats Bay at the request of a potential shellfish harvester. Forty-six developed parcels, 27 drainage/discharge points, 3 agricultural practices and other activities were evaluated. No direct or indirect impacts were identified. However, several potential fecal sources were identified, including three on-site sewage systems, two agricultural sites, and boats moored in the bay. There is no boat waste pump-out station available.

Figure MTS-1. Status of Trends in Fecal Pollution in Mats Mats Bay Through December 2001



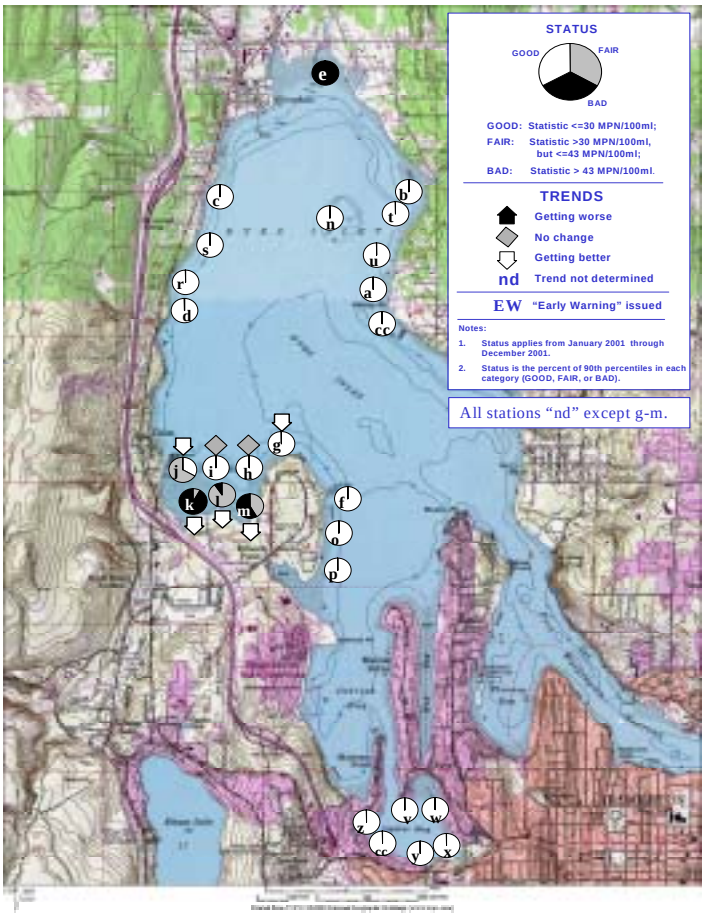
Status and Trends: Trends were not determined for stations in Mats Mats Bay because the data record was very short. In addition, status shown in Figure MTS-1 was based on a single statistic calculated from far fewer than the 30 fecal coliform results called for by the National Shellfish Sanitation Program. Thus, status can be termed only tentative, until sampling for certification is completed.

Kitsap County

Dyes Inlet (Chico Bay)

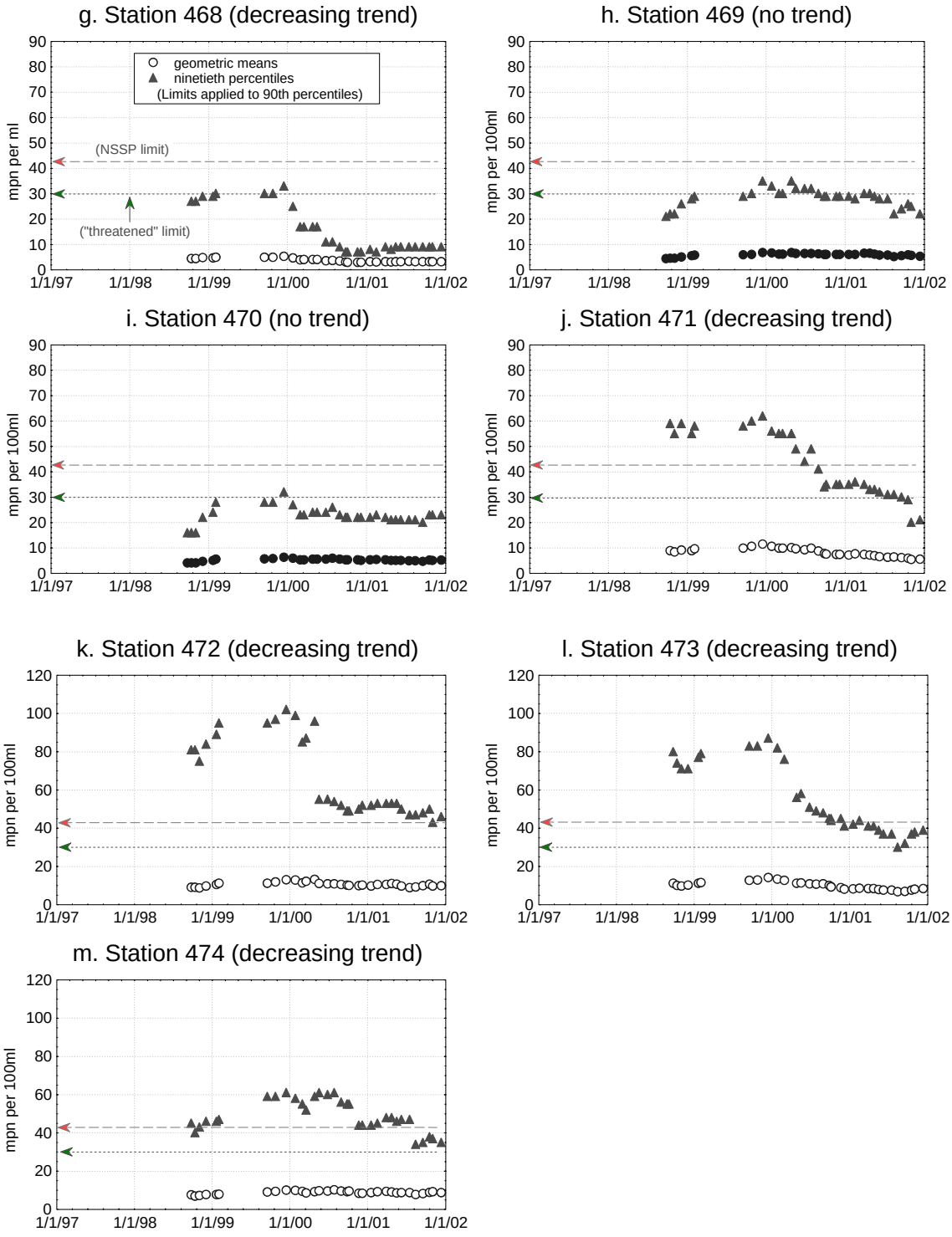
Background: Shellfish harvest in Dyes Inlet was stopped in the 1950s due to nonpoint sources and raw sewage discharges. Most sewage is treated prior to discharge, but the City of Bremerton still discharges some sewage mixed with stormwater during heavy rainfall ("combined sewer overflows" or CSOs). In early 1993, the Washington State Department of Health (DOH) began sampling in Chico Bay. DOH reclassified Chico Bay as **Restricted** to allow relay of shellfish from Chico Bay to cleaner waters. In 1995, the Kitsap County Health Department (KCHD) conducted a program to find and fix failed on-site sewage systems. DOH and KCHD recently conducted joint shoreline surveys of Chico Bay, the east and western shores of Dyes Inlet, and upland drainages. Four failed on-site sewage systems were found and repaired. Although surveyors didn't locate any direct fecal discharges, water sampling by KCHD (1996-1999) showed that Chico and Barker Creeks violated the freshwater fecal criteria of the State Water Quality Standards. DOH expanded marine water sampling to the rest of Dyes Inlet in late 1999.

Figure DYS-1. Status and Trends of Fecal Pollution in Dyes Inlet Through December 2001



Status and Trends: Station 466 at the mouth of Clear Creek near Silverdale ("e" in Fig. DYS-1) was categorized as **BAD** on each sampling date in calendar year 2001. Four of seven sites in Chico Bay showed mixed fecal impact. Sites closest to Chico Creek showed the greatest impact. The status of the remaining sites was **GOOD** (although based on only 1 statistic). Trends were analyzed at 7 stations in Chico Bay where records were long enough. These are shown plotted over time in Figure DYS-2. Five stations showed improving trends.

Figure DYS-2. Fecal Pollution Over Time in Dyes Inlet



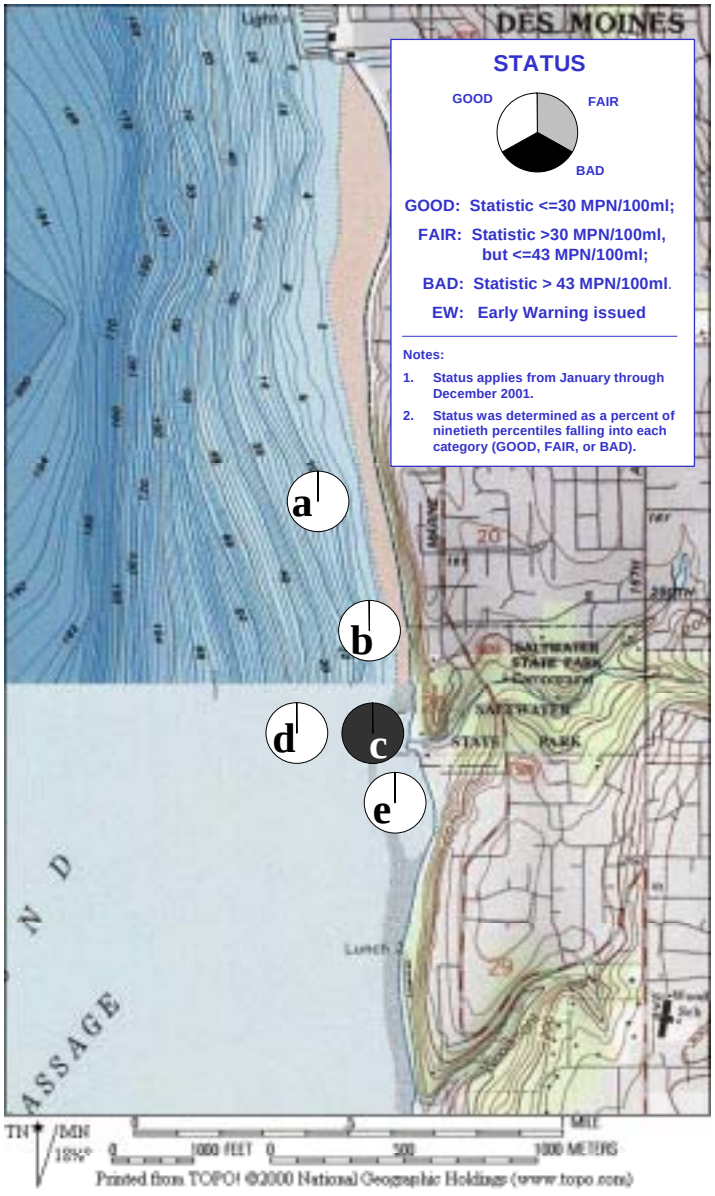
(Note: trends were tested for statistical significance with Spearman's R)

King County

Saltwater State Park

Background: The Washington State Department of Health (DOH) began sampling off Saltwater State Park in February 2000 at the request of the Puyallup Tribe. The Tribe is interested in harvesting intertidal and subtidal shellfish in the area. By the end of December 2001, about half of the minimum number of samples required for classification (30 per station) had been taken. Saltwater State Park has not yet been classified for harvest because upland sanitary surveys and sampling of drainages are still underway.

Figure SSP-1. Status of Fecal Pollution at Saltwater State Park Through December 2001



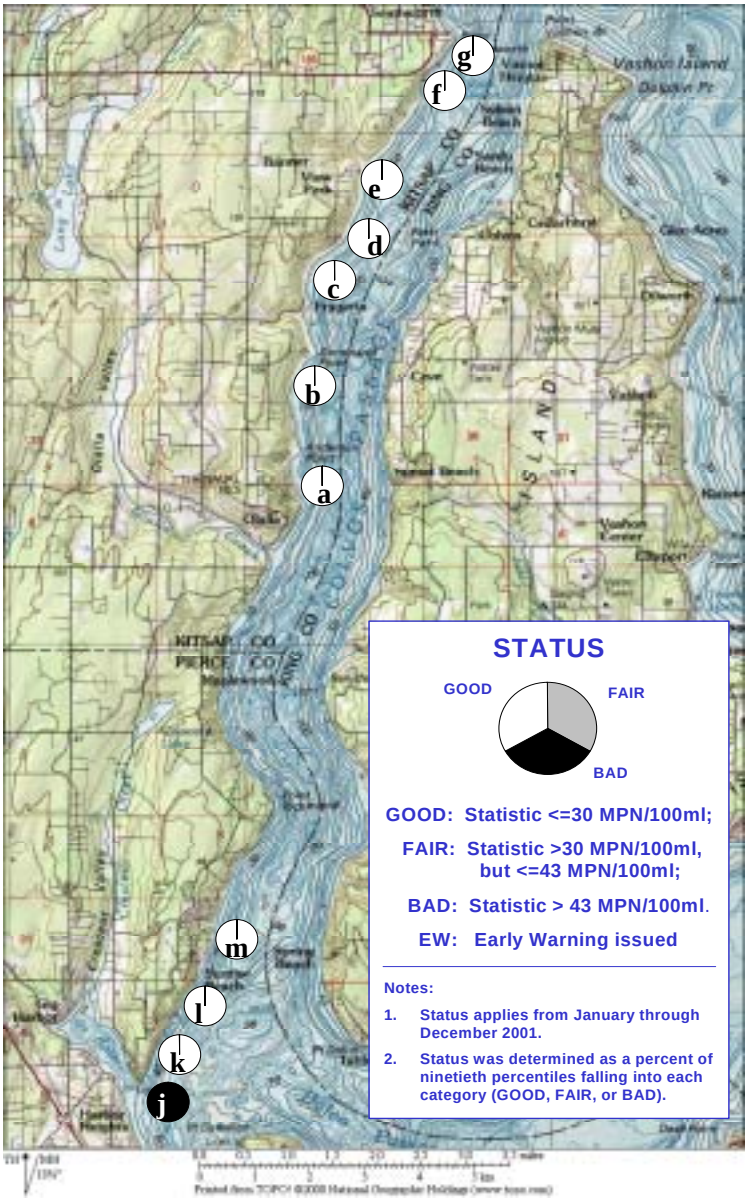
Status and Trends: Status was determined from a single statistic calculated from limited data. So status must be termed tentative. Station 570 ("c" in Figure SSP-1) was **BAD.** Station 570 is located at the mouth of a small stream flowing through an urban residential area. The remaining stations were **GOOD**. Due to the limited data record, trends were not determined.

King County

Colvos Passage

Background: The Washington State Department of Health (DOH) began sampling of Colvos Passage in January 2001 at the request of a consortium of tribes. The group is interested in harvesting intertidal and subtidal shellfish in the area. By the end of December 2001, less than half of the minimum number of samples required for classification (30 per station) had been taken. Colvos Passage has not yet been classified for harvest because upland sanitary surveys and sampling of drainages are still underway.

Figure CLV-1. Status of Fecal Pollution in Colvos Passage Through December 2001



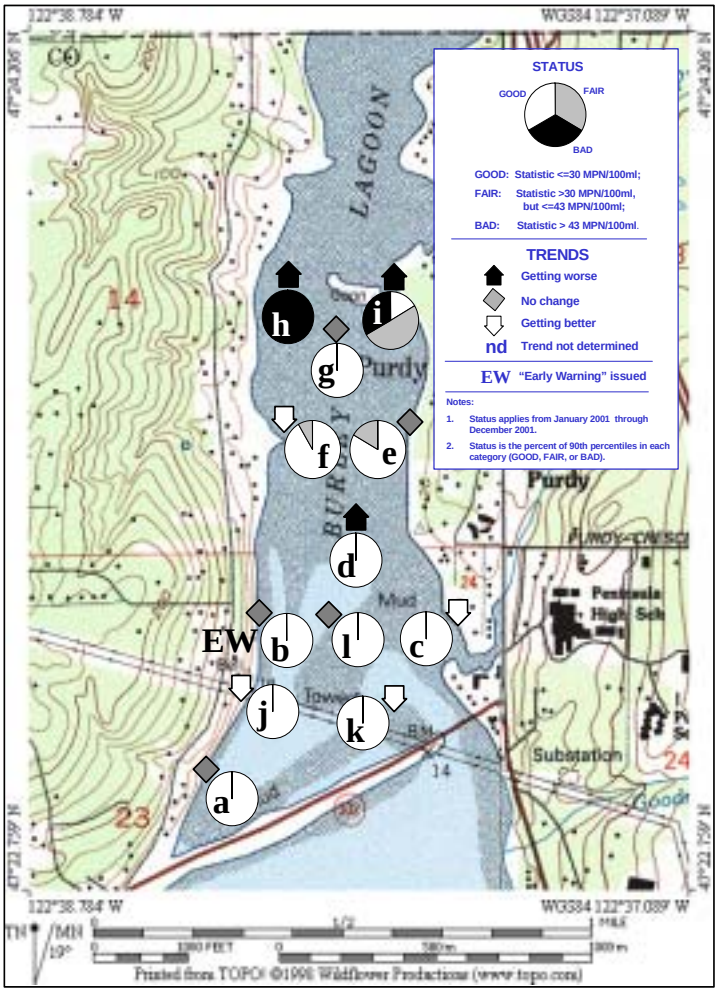
Status and Trends: Status was determined from a single statistic calculated from limited data. So status must be termed tentative, and trends were not determined. All stations were **GOOD**, except for Station 560 ("j" in Figure CLV-1) located at the mouth of Gig Harbor. Station 560 was **BAD.** Sources of fecal coliform affecting Station 560 are probably creeks and drains along the urbanized shoreline and upper watershed of Gig Harbor.

Kitsap and Pierce Counties

Burley Lagoon

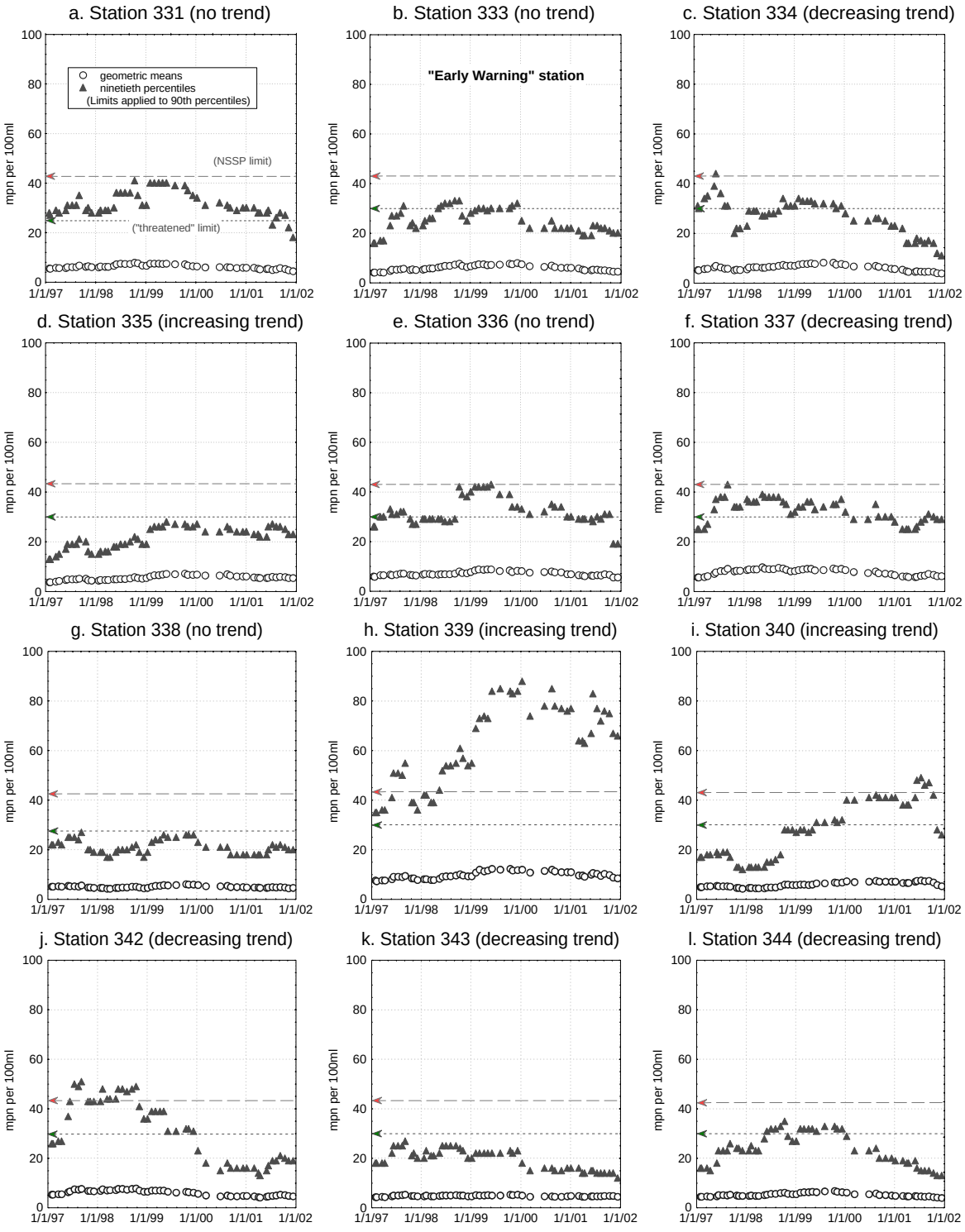
Background: Shellfish beds in Burley Lagoon were downgraded in 1981 from **Approved** to **Restricted** due to nonpoint fecal sources from its watershed. After intensive studies and remedial action (pasture management and repair of individual on-site sewage systems), Burley Lagoon was upgraded from **Restricted** to **Conditionally Approved** in 1993. But by early 1997, water quality once again began to decline. Burley Lagoon was reclassified **Restricted** in early 1999. Local agencies redoubled intensive remedial action. By Spring 2001, the southern end of Burley Lagoon had improved sufficiently to allow an upgrade to **Approved**.

Figure BRL-1. Status and Trends of Fecal Pollution in Burley Lagoon Through December 2001



Status and Trends: Eight of 12 stations in Burley Lagoon were categorized as **GOOD** on each sampling date in calendar year 2001. These are located mostly in the south end. Three shoreline stations in the north end had a mixture of sampling dates (Figure BRL-1, "e", "f", and "i"), and one station was categorized as **BAD** on each sampling date ("h" in Figure BRL-1). The trend at 4 stations was improving, and 5 more were stable. Generally conditions this year represent improvement over recent years. The trends at three stations in the north end suggest worsening conditions, but individual graphs of two of these stations (Figure BRL-2h, i) suggest a slight recent improvement. In early 2002 DOH listed Station 333 ("b" in Figure BRL-1) as **Threatened** under the Early Warning system.

Figure BRL-2. Fecal Pollution Over Time at Stations in Burley Lagoon



(Note: trends were tested for statistical significance with Spearman's R)

Kitsap and Pierce Counties

Henderson Bay (Minter Bay)

Background: In 1982, Minter Bay was downgraded from **Approved** to **Prohibited**. Waters outside Minter Bay remained **Approved**. Water quality studies and nonpoint remedial action in the Minter watershed were taken through the early '90s. No improvement occurred. Data analysis by the Washington State Department of Health (DOH) in 1994 suggested shoreline sources were the main problem. The rest of Henderson Bay has been sampled since the early 1990s. In 2001 DOH performed a sanitary survey of Henderson Bay in part with data from Tacoma-Pierce County Health District. Results suggested the size of one proposed harvest area might be reduced.

Status and Trends: Twelve of 16 stations throughout Henderson Bay were categorized as **GOOD** on each sampling date in calendar year 2001 (Figure HNB-1). Three stations inside Minter Bay were categorized as **BAD** (tentative conclusion based on a single statistic). Station 298 ("b" in figure HNB-1) outside Minter Bay had mixed status. Five stations had records long enough or statistics high enough to warrant trend analysis. Three stations showed increasing pollution. In early 2002 DOH listed Station 305 ("i" in Figure HNB-1) as **Threatened** under the Early Warning system. Figure HNB-2 shows graphs of selected stations.

Figure HNB-1. Status and Trends of Fecal Pollution in Henderson Bay Through December 2001

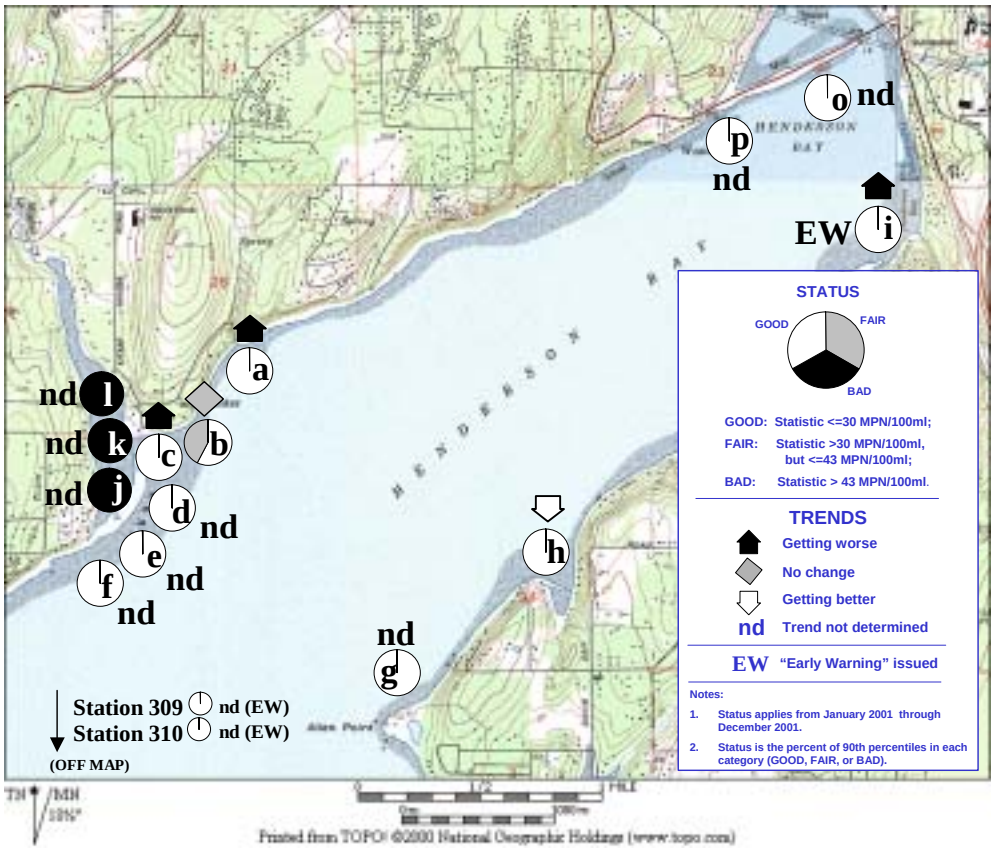
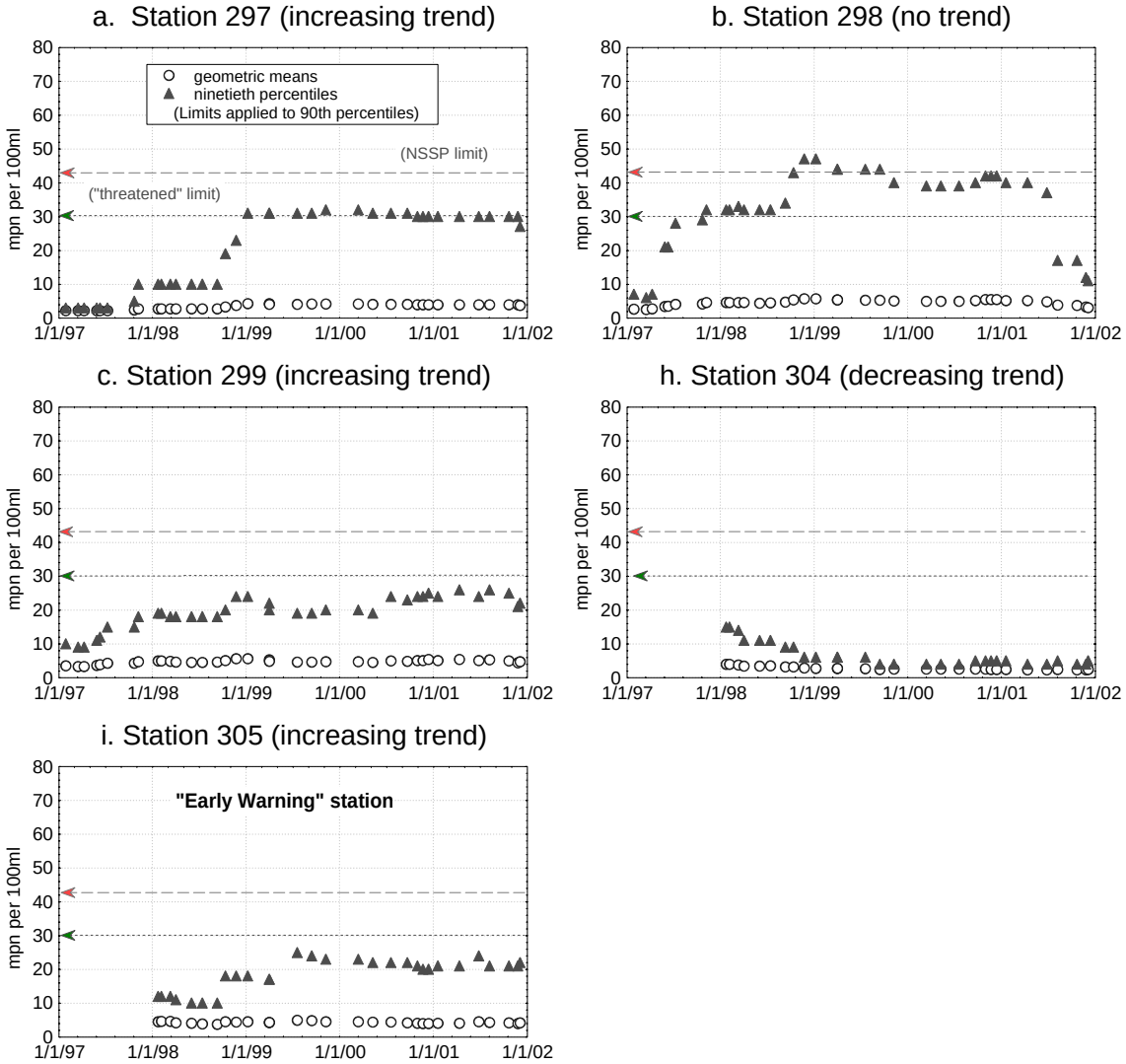


Figure HNB-2. Fecal Pollution Over Time at Stations in Henderson Bay



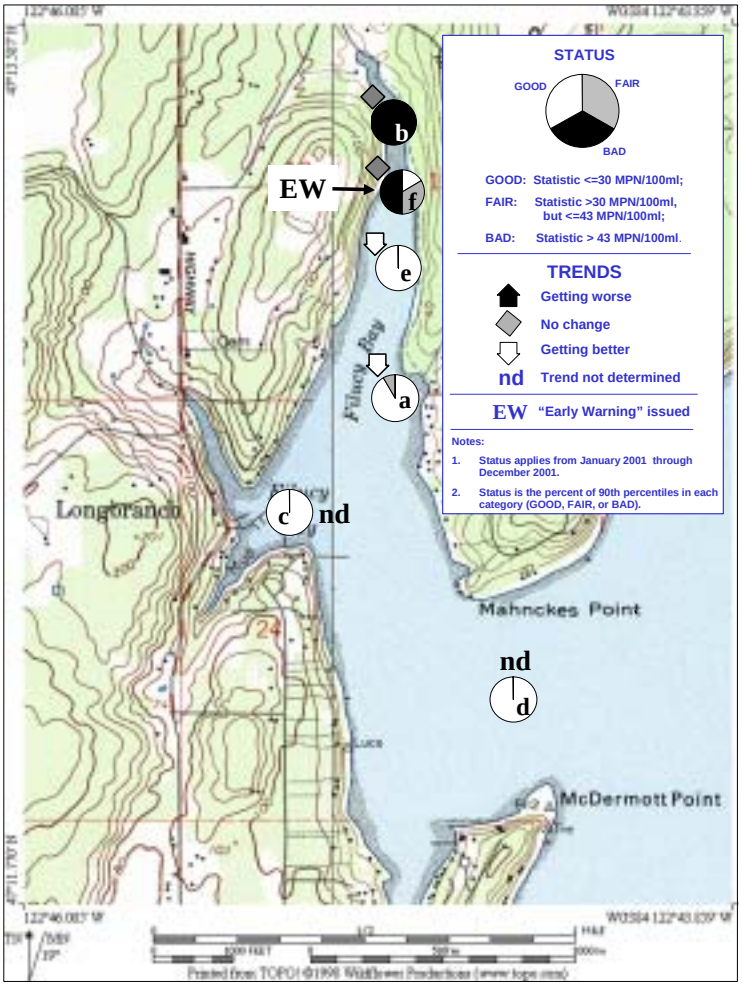
(Note: trends were tested for statistical significance with Spearman's R)

Pierce County

Filucy Bay

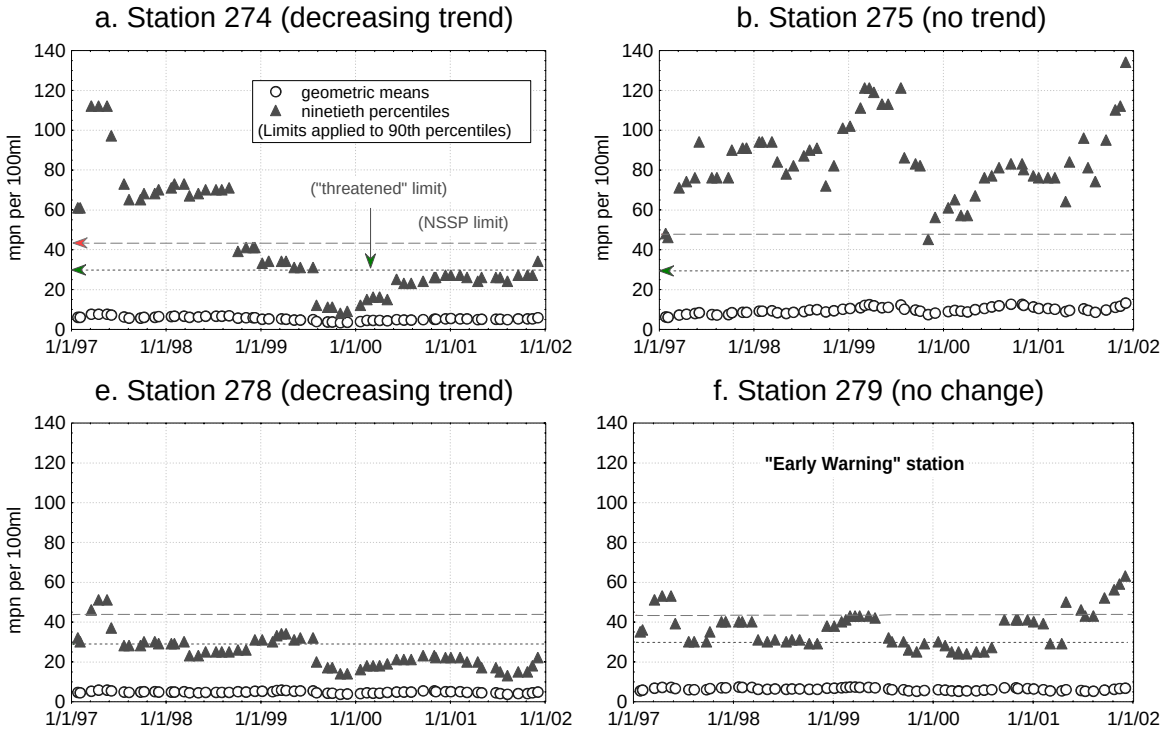
Background: Prior to 1994, all of Filucy Bay was classified as **Conditionally Approved** due to seasonally high occupancy of the Longbranch Marina. In that year, a permanent closure was placed around the marina and a rainfall-based **Conditionally Approved** classification was placed on the remainder of Filucy Bay. The Washington State Department of Health (DOH) performed shoreline surveys in 1994 and 1999. Although no failed systems were found, soil conditions were generally unsuitable for adequate on-site system function. Also, nine parcels held pastured livestock. Roughly 25 percent of the animals had direct access to water. DOH downgraded the northern end of Filucy Bay from Conditionally Approved to Restricted in late 2001.

Figure FLC-1. Status and Trends of Fecal Pollution in Filucy Bay Through December 2001



Status and Trends: The northernmost stations in Filucy Bay suffered the greatest effect from fecal pollution in calendar year 2001 (Figure FLC-1). Although stations 275 and 279 (Figure FLC-1,"b" and "f") show no significant change since January 1997, the graphs in figures FLC-2b, f show that statistics went up in 2001. Statistics for stations 274 and 278 (Figure FLC-1, "a" and "e") also increased in 2001, although the overall trend had been toward improvement. DOH listed Station 279 ("f" in Figure FLC-1) as **Threatened** under the Early Warning System.

Figure FLC-2. Fecal Pollution Over Time at Stations in Filucy Bay



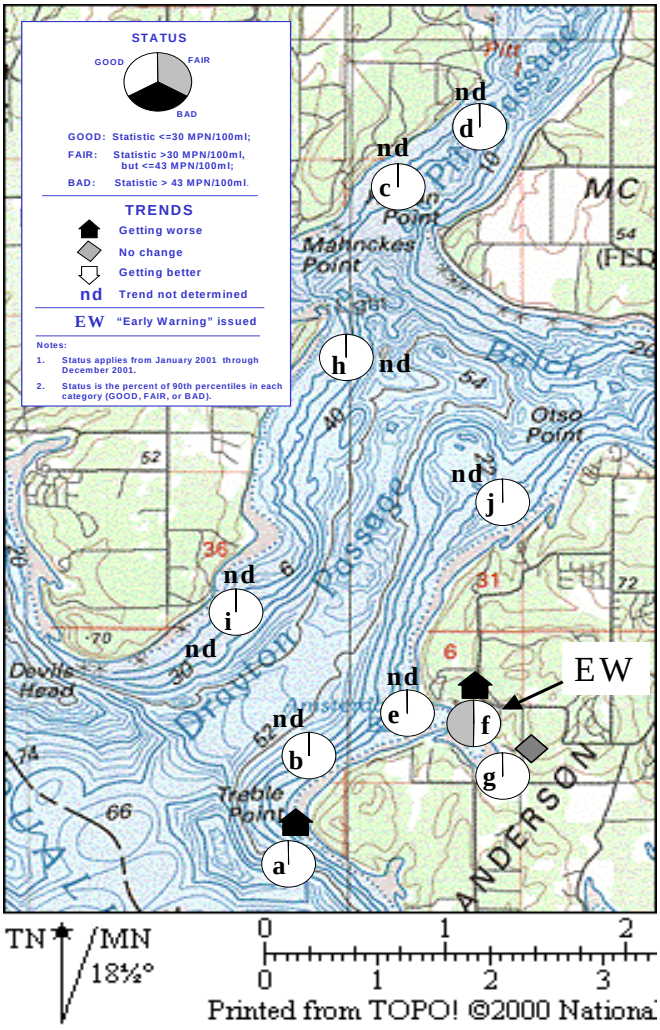
(Note: trends were tested for statistical significance with Spearman's R)

Pierce County

Drayton Passage

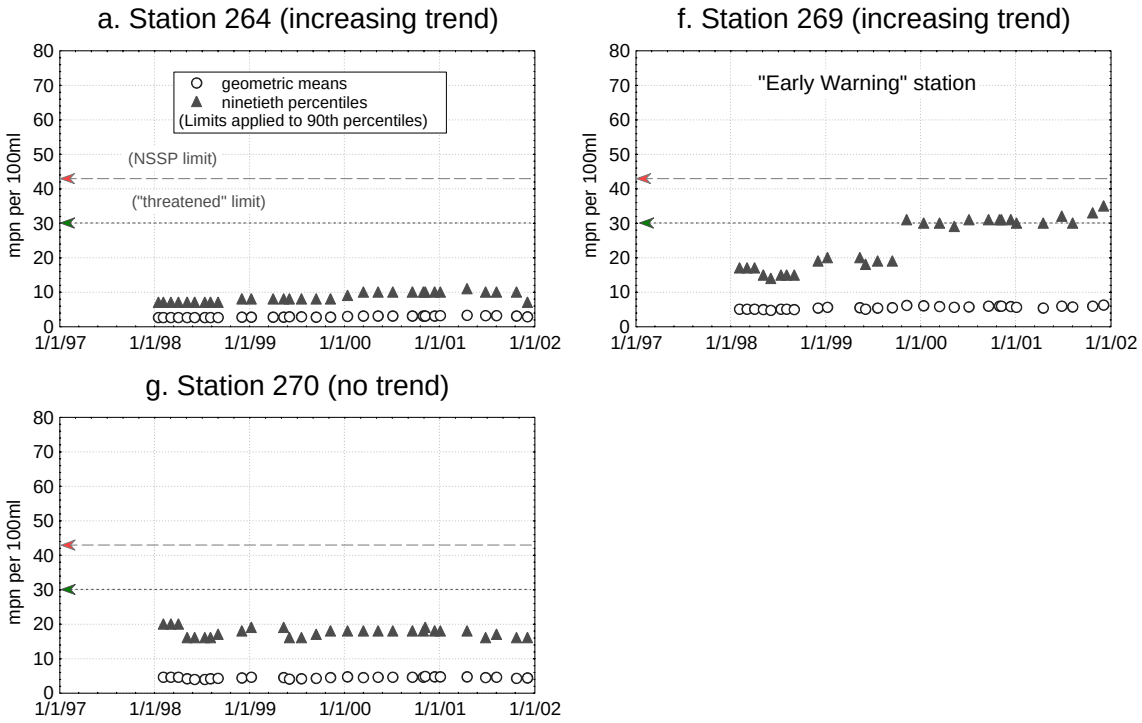
Background: The Drayton Passage growing area includes both intertidal and subtidal shellfish beds off the west side of Anderson Island and subtidal beds in Drayton Passage and Pitt Passage. The area has been classified **Approved** since 1995 following a completion of a shoreline survey at Treble Point and Amsterdam Bay (west side of Anderson Island) and the southeast shore of Key Peninsula. No direct pollution sources were found, although there were "indirect" sources (greywater discharges or on-site sewage systems within 50 feet of the shore). The Washington State Department of Health (DOH) is currently evaluating a request for new harvest sites from the Washington State Department of Natural Resources and the Nisqually Tribe. A shoreline survey conducted in 2002 discovered three "potential" pollution sources (due to age, type of on-site system, or location).

Figure DRP-1. Status and Trends of Fecal Pollution in Drayton Passage Through December 2001



Status and Trends: Station 269 ("f" in Figure DRP-1) in Amsterdam Bay was evenly split between **GOOD** and **FAIR** categories on sampling dates in calendar year 2001 (Figure DRP-1). DOH listed Station 269 as **Threatened** in the Early Warning system in early 2002. This station also worsened (Figure DRP-2f). Station 264 ("a" in Figure DRP-1) also worsened, although pollution was well below the **Threatened** limit. The rest of the stations were categorized as **GOOD** on each sampling date in 2001. Trends at these remaining stations were not determined due to minimal pollution and/or short data records.

Figure DRP-2. Fecal Pollution Over Time at Stations in Drayton Passage



(Note: trends were tested for statistical significance with Spearman's R)

Pierce County

Oro Bay

Background: There are two state-owned public beaches near Oro Bay, and there are commercial quantities of geoducks. The Washington State Department of Health (DOH) conducted shoreline surveys in 2000. One failed on-site sewage system was discovered out of 51 properties inspected. Limited animal grazing occurs in upland pastures. During peak boating periods, 80 or more boats gather around a marina in Oro Bay. DOH has established a marina closure zone appropriate to its capacity. The surrounding area is closed pending further water sampling and correction of pollution sources.

Status and Trends: Seven stations were categorized as **GOOD** on each sampling date in calendar year 2001. Station 554 near the marina ("g" on Figure ORO-1) was **BAD** on each sampling date. Nearby Station 257 (Figure ORO-1"d") was **BAD** nearly half the time, and was listed as **Threatened** by the Early Warning System in early 2002. Four stations have worsened. Trends at the remaining stations were not determined because of short data records. Figure ORO-2 shows graphs of 4 selected stations.

Figure ORO-1. Status and Trends of Fecal Pollution in Oro Bay Through December 2001

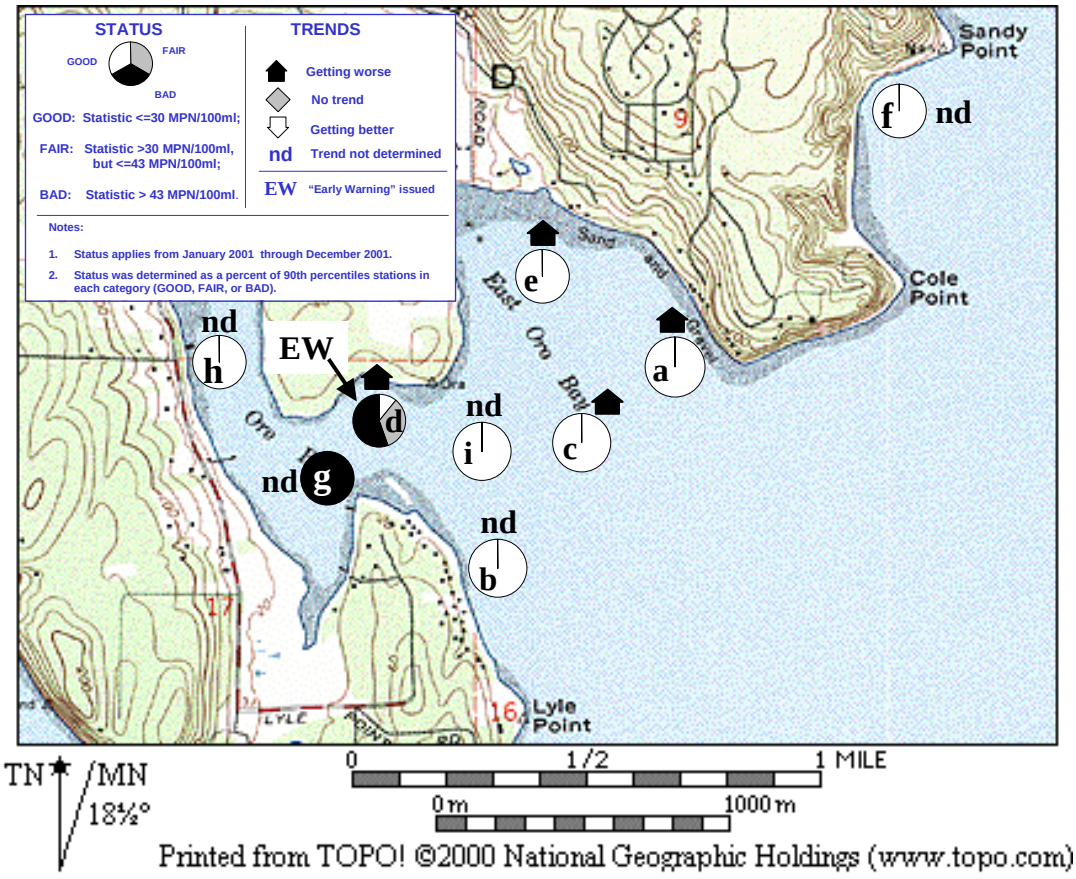
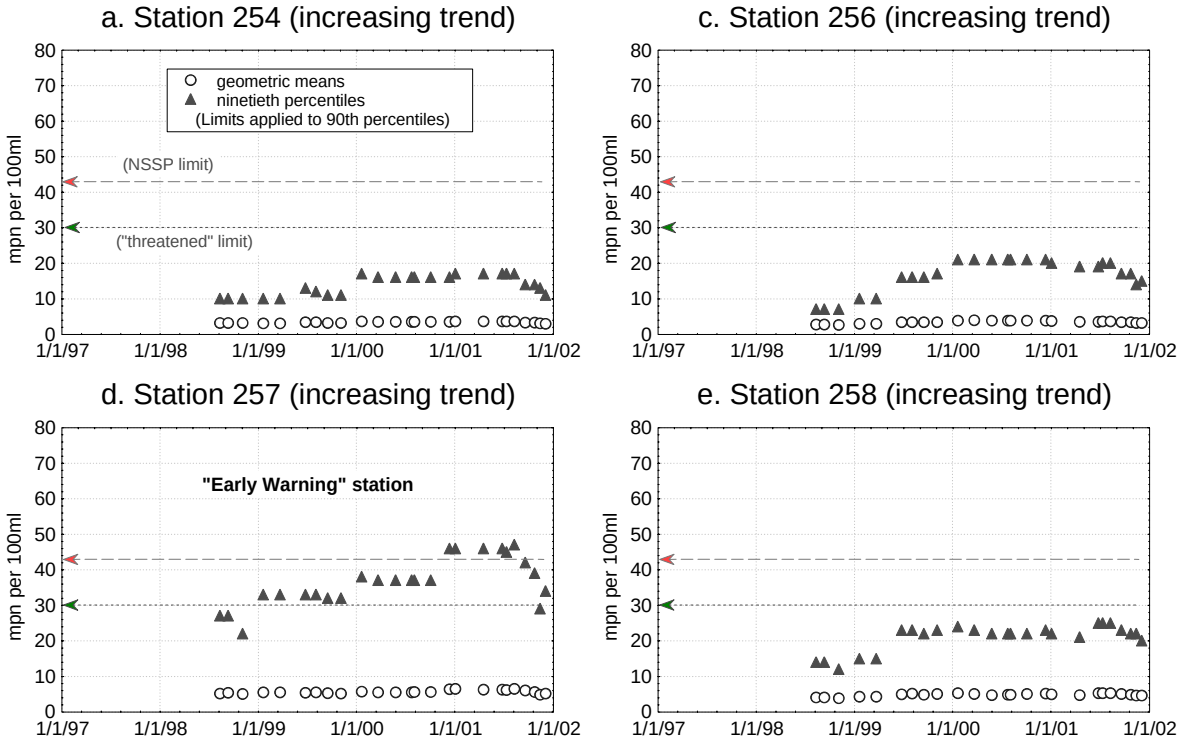


Figure ORO-2. Fecal Pollution Over Time at Stations in Oro Bay



Thurston and Pierce Counties

Nisqually Reach (Hogum Bay)

Background: The Washington State Department of Health (DOH) downgraded Hogum Bay to **Conditionally Approved** in 1992. During remedial action, several farms adopted best management plans. During voluntary inspections from 1994-1996, Thurston County found that 26% of on-site sewage systems along Hogum Bay had failed. Later surveys indicated a failure rate of 29% along the shore northwest of Hogum Bay. All systems were eventually repaired. In October 2000, DOH changed the east end of the **Conditionally Approved** zone to **Restricted** and upgraded the west end to **Approved.** In July 2002, DOH upgraded the offshore part of the **Restricted** area to **Approved**.

Status and Trends: All but one station in Hogum Bay were categorized as **GOOD** on each sampling date during calendar year 2001. Station 225 ("d" in Figure NSQ-1) was **FAIR** on 25% of sampling dates. Stations closest to the Nisqually River and McAllister Creek were **BAD** on all dates. These stations were also getting worse. Station 223 near Beachcrest (Figure NSQ-1 "b") was **FAIR (**based on a single statistic). Stations 223 and 234 nearest McAllister Creek showed the highest statistics of all stations (Figure NSQ-2c, m). DOH listed stations 245-247 ("x-z" in Figure NSQ-1) as **Threatened** under the Early Warning System.

Figure NSQ-1. Status and Trends of Fecal Pollution in Nisqually Reach Through December 2001

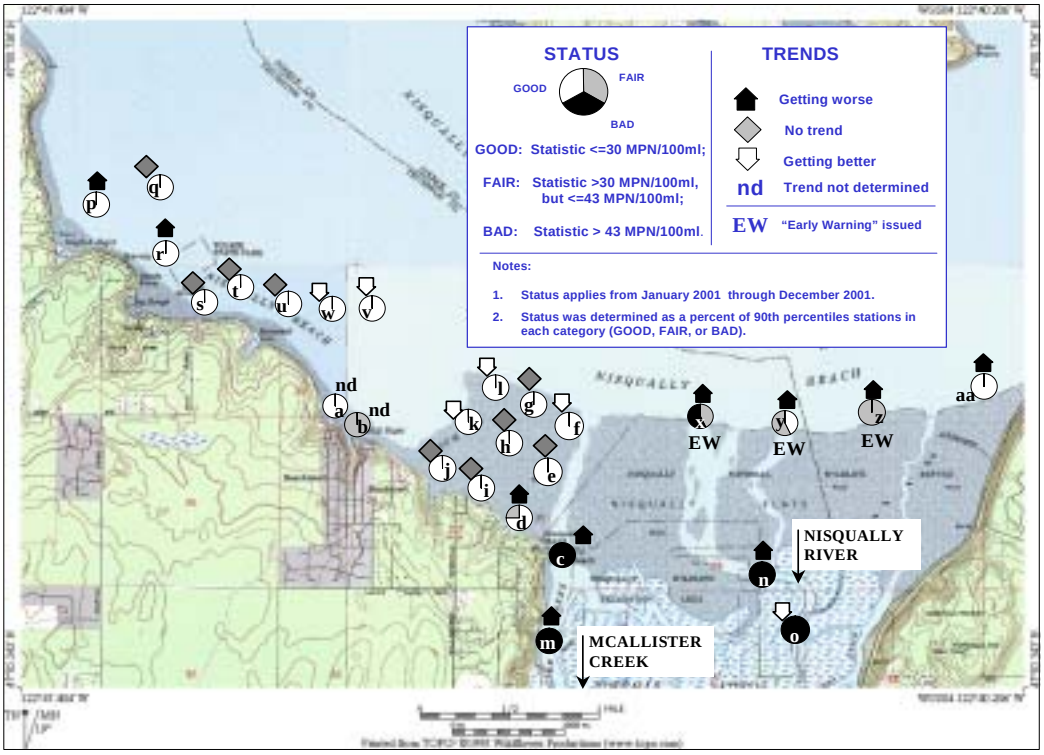
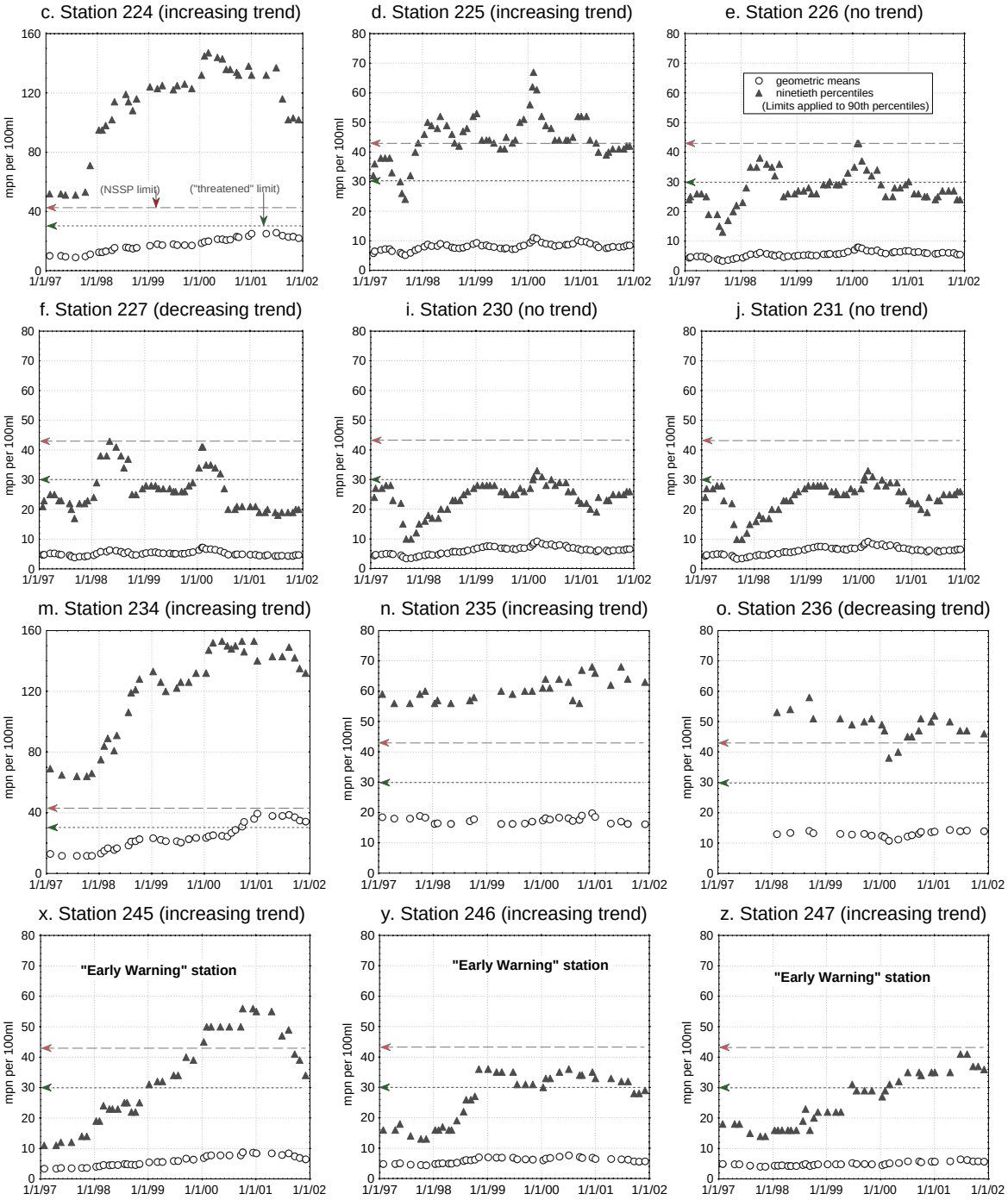


Figure NSQ-2. Fecal Pollution Over Time at Stations in Nisqually Reach



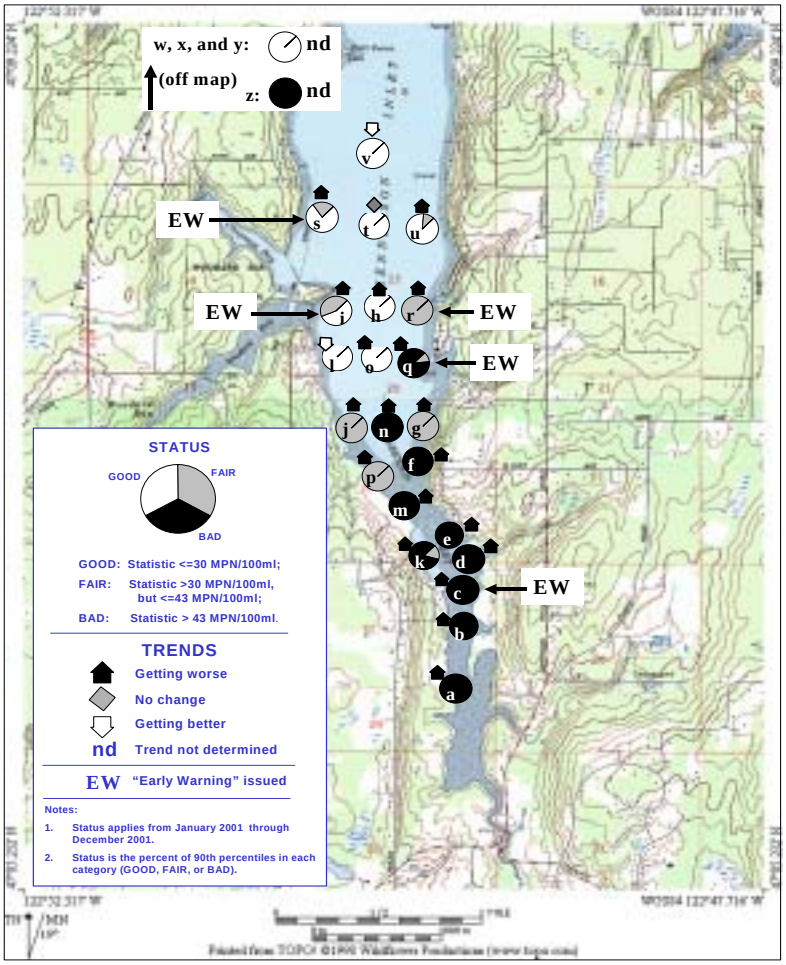
(Note: trends were tested for statistical significance with Spearman's R)

Thurston County

Henderson Inlet

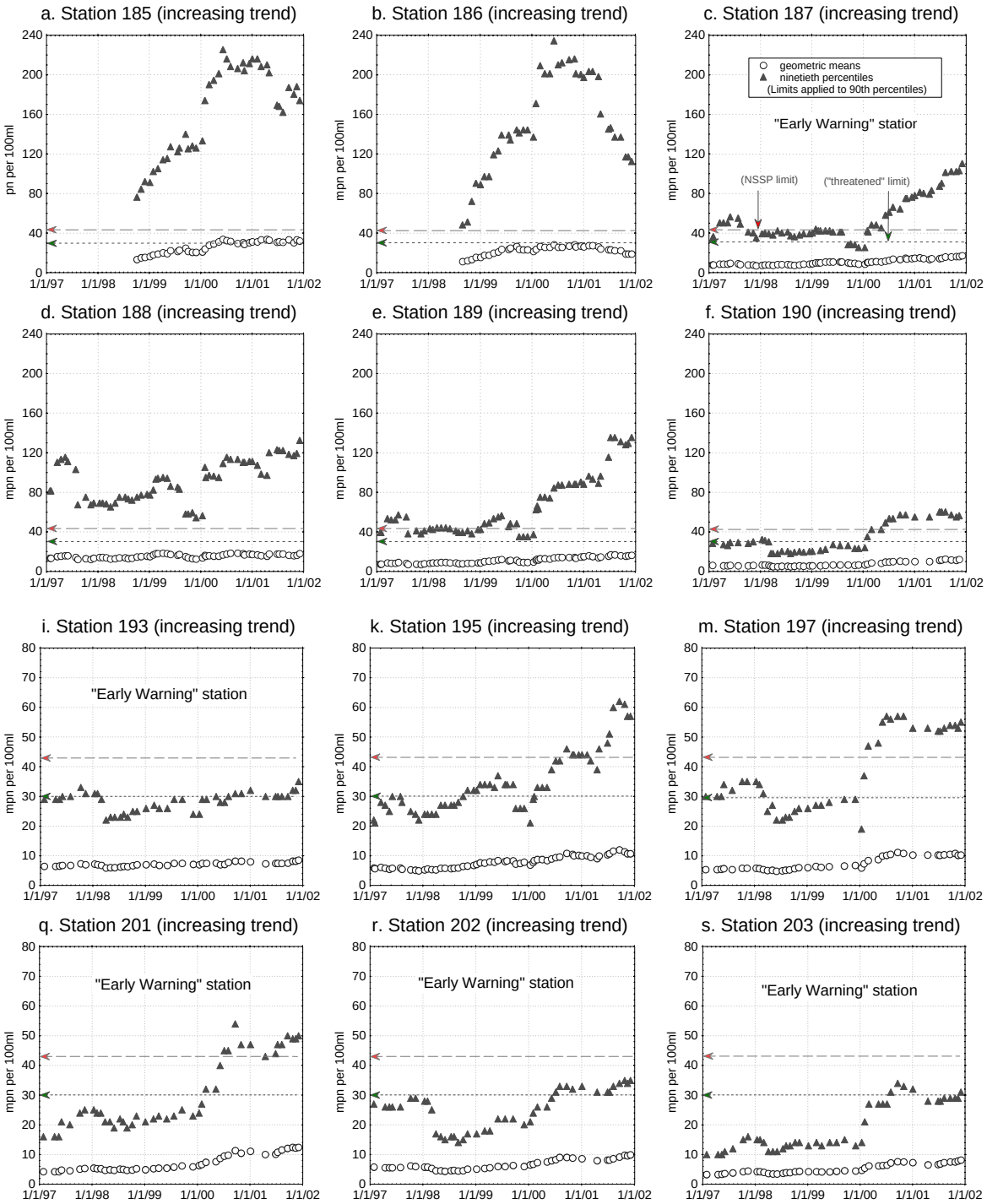
Background: In 1983, the south end of Henderson Inlet was downgraded to **Conditionally Approved**. In 1985, the southernmost part of this area was classified **Prohibited**. Primary sources of fecal pollution were failed on-site systems and inadequate pasture management from uplands and the marine shoreline, and contaminated urban stormwater from the urbanized upper watershed. Despite control measures (voluntary farm management practices, repair of failed on-site systems, updated standards for on-site sewage standards, land-use density limits, stormwater management, etc.), contamination has intensified. During 1996-1999 on-site sewage system surveys, Thurston County estimated failure rate to be 14% (based on voluntary cooperation). The Washington State Department of Health **(**DOH) recently expanded both **Prohibited** and **Conditionally Approved** areas.

Figure HNL-1. Status and Trends of Fecal Pollution in Henderson Inlet Through December 2001



Status and Trends: Eight of 26 stations examined were categorized as **GOOD** on each sampling date during calendar year 2001. Nine were categorized as **BAD** and 4 were **FAIR** on each sampling date. The remaining 5 stations were mixed **GOOD**, **FAIR**, and **BAD** (Figure HNL-1). Trend analysis indicated that 19 stations show increased pollution, 2 stations were reduced, and 1 station showed no change. Four stations were not evaluated for trend due to short record. Figure HNL-2 shows individual plots for selected stations, including five listed as **Threatened** by DOH's Early Warning system.

Figure HNL-2. Fecal Pollution Over Time in Henderson Inlet



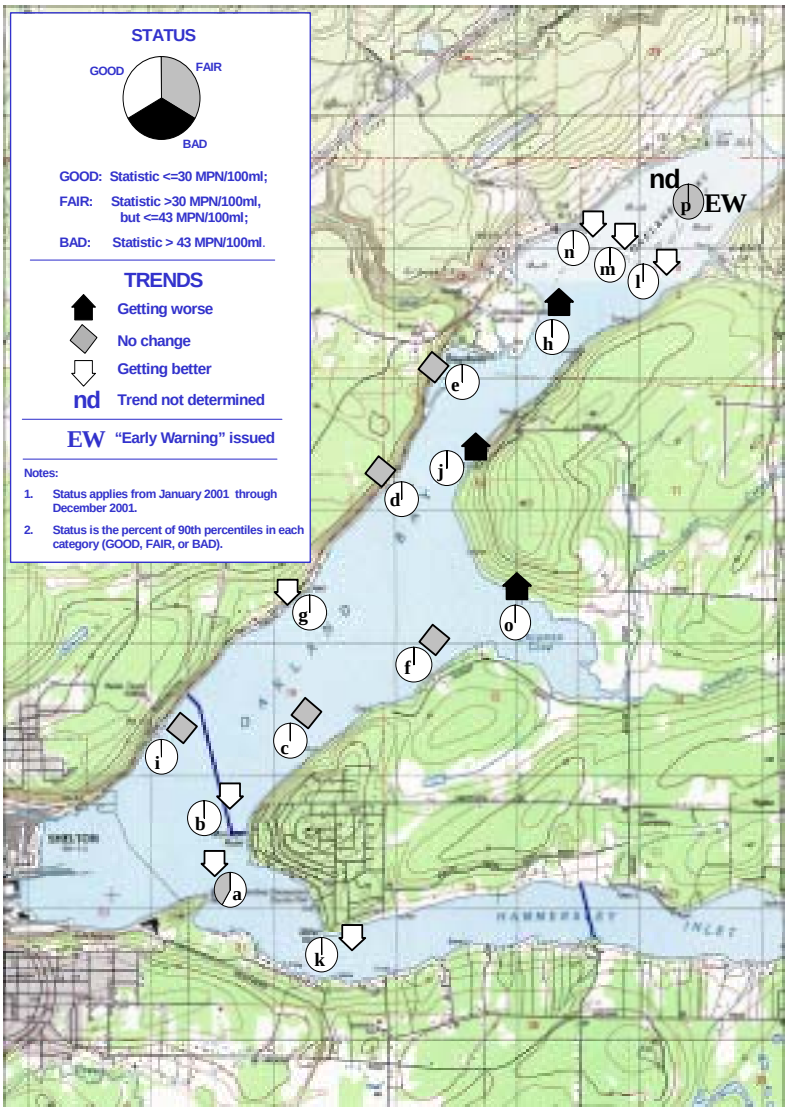
(Note: trends were tested for statistical significance with Spearman's R)

Mason County

Oakland Bay

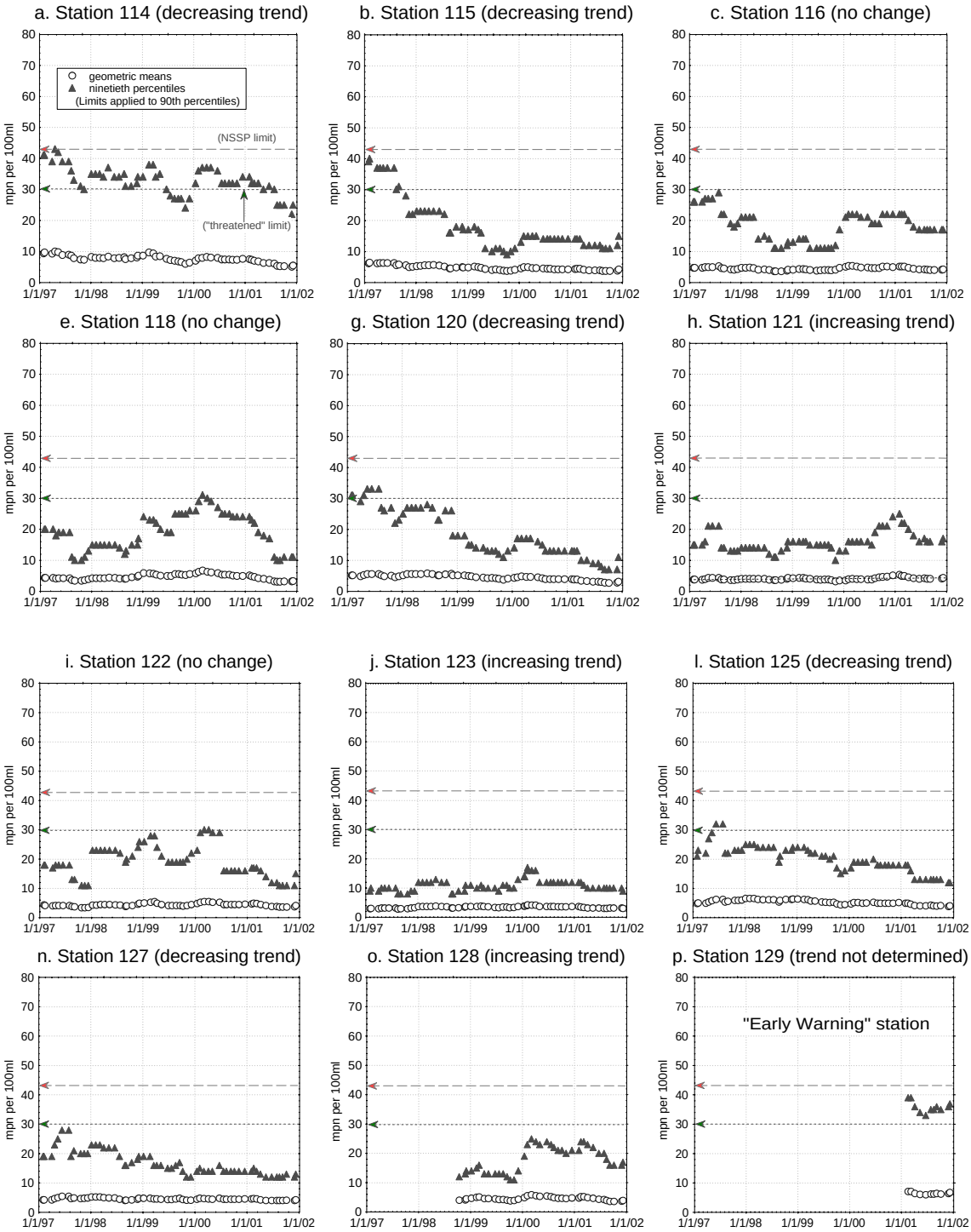
Background: The southwestern end of Oakland Bay is permanently closed to shellfish harvest due to the discharge of the Shelton Sewage Treatment Plant (STP) and other nonpoint sources. The remainder of Oakland Bay was downgraded to **Restricted** in 1987. Infiltration and inflow into Shelton's aging sewer collection system caused overflowing sewage to mix with storm water runoff during storms. In 1989, following initial remedial action, the Washington State Department of Health (DOH) upgraded the **Restricted** part of Oakland Bay to **Conditionally Approved**. In recent years, many of the sewer lines in downtown Shelton have been renovated, and collection lines have been installed in new areas.

Figure OKL-1. Status and Trends of Fecal Pollution in Oakland Bay Through December 2001



Status and Trends: All but two of 16 stations were categorized as **GOOD** on each sampling date in calendar year 2001. Station 114 near the Shelton STP outfall ("a" on Figure OKL-1) was categorized as **FAIR** on nearly half the sampling dates. Station 129 at the northeast end of Oakland Bay ("p" on Figure OKL-1) was categorized as **FAIR** on each sampling date. Overall trends have improved at seven stations since January 1997. Five stations have not measurably changed. Three stations have worsened. DOH listed Station 129 ("p" in Figure OKL-1) in its Early Warning System in early 2002. However, its record is currently too short to assess trend. Figure OKL-2 shows graphs for selected stations in Oakland Bay.

Figure OKL-2. Fecal Pollution Over Time in Oakland Bay



(Note: Trends were tested for statistical significance with Spearmans's R.)

Mason County

Hammersley Inlet

Background: A sanitary survey of Hammersley Inlet conducted by the Washington State Department of Health (DOH) in 1993 confirmed its classification as **Approved**. In 1994, DOH conducted a shoreline survey of 211 shoreline parcels, including full-time residences, vacations homes, a small farm and two commercial facilities. Subsequent data analysis indicated the area near the mouth of Mill Creek wouldn't meet **Approved** status. In early 1997 the creek mouth was reclassified from **Approved** to **Inactive** since no active harvest was occurring. This was changed to Unclassified in 2001.

Status and Trends: Ten of 12 stations in Hammersley Inlet were categorized as **GOOD** on each sampling date in calendar year 2001. Station 104 near the west end ("i" on Figure HMR-1) was categorized as **FAIR** on most sampling dates. Station 100 near the mouth of Mill Creek ("e" on Figure HMR-1) was **BAD** on most sampling dates. However, trend analysis showed improvement (see Figure HMR-2e). Four other stations show significant improvement. Trends at the rest of the stations were not determined due to very low pollution. The graphs on Figure HMR-2 suggest very slight reduction of pollution at some stations in 2001, but the time frame was too short to be significant.

Figure HMR-1. Status and Trends of Fecal Pollution in Hammersley Inlet Through December 2001

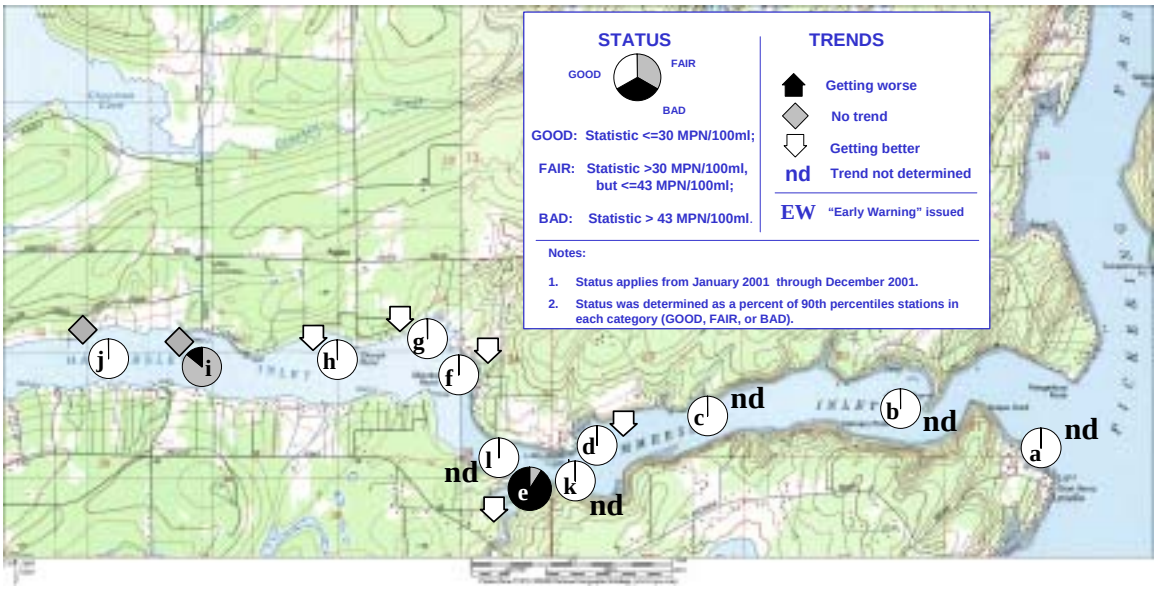
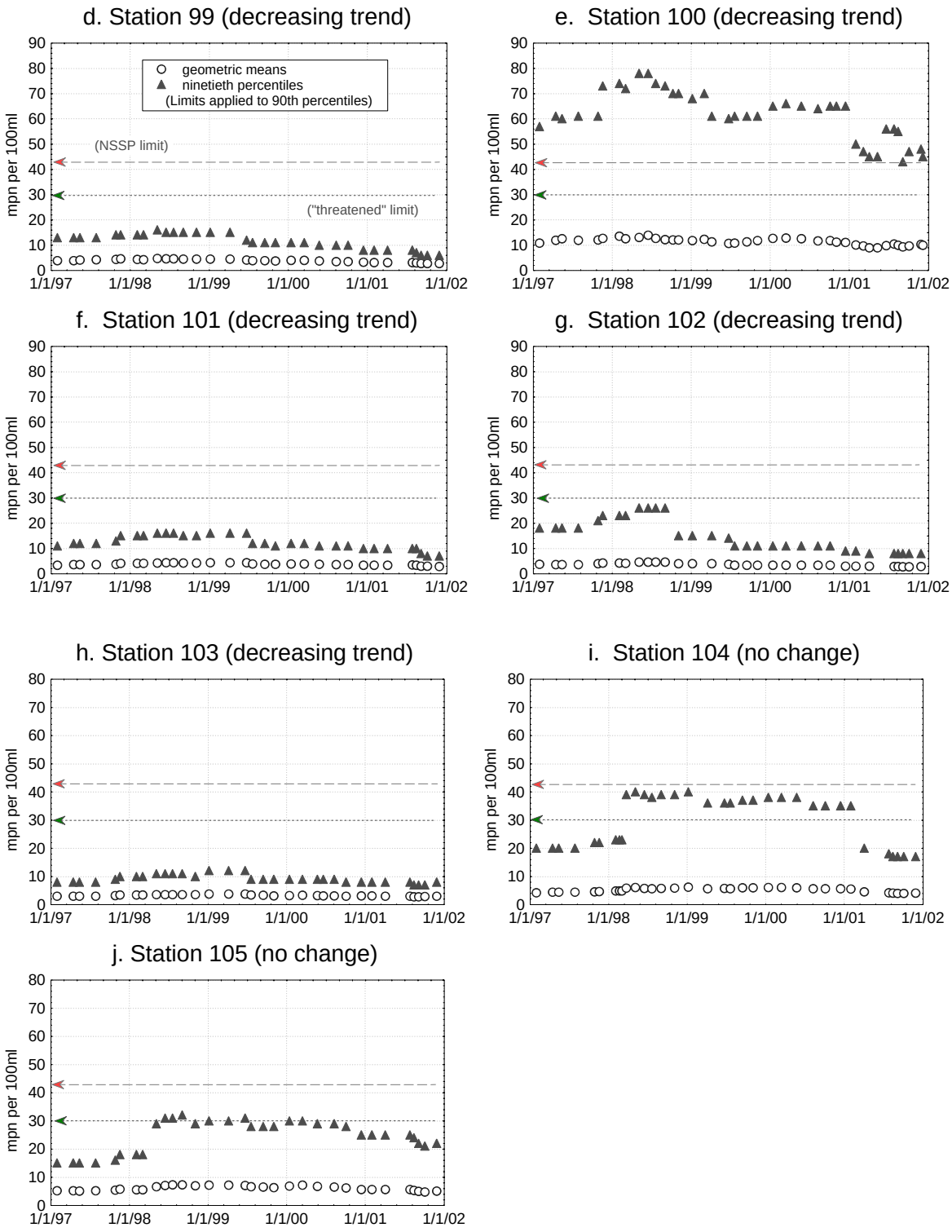


Figure HMR-2. Fecal Pollution Over Time at Stations in Hammersley Inlet



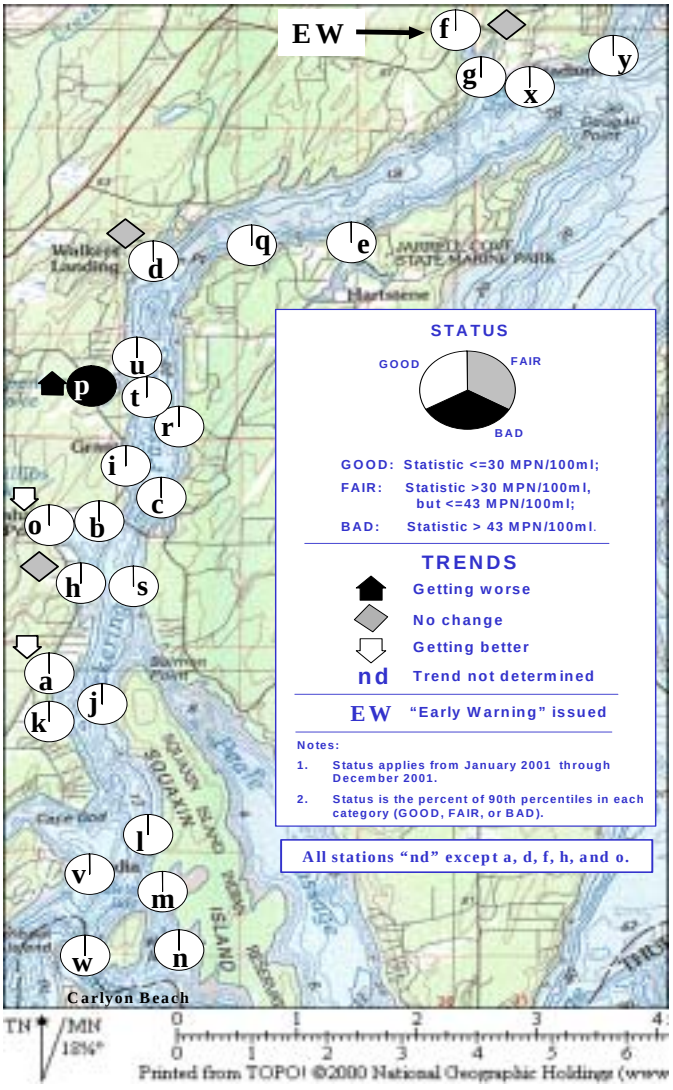
(Note: Trends were tested for statistical significance with Spearmans's R.)

Mason County

Pickering Passage

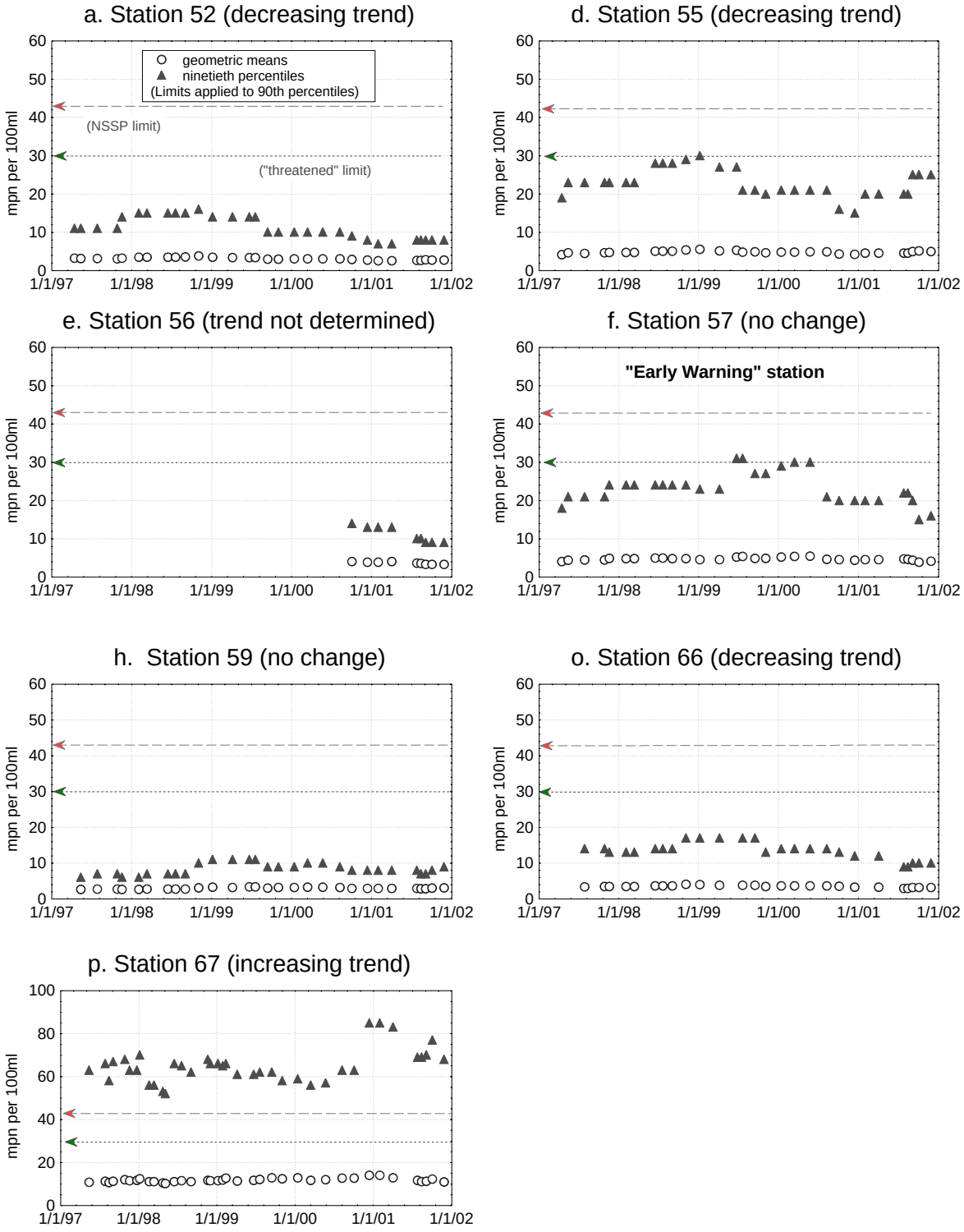
Background: There are a number of commercial shellfish growing areas and two public access beaches (Washington State Department of Natural Resources) in Pickering Passage. The Squaxin Tribe also has a number of beaches, particularly on Squaxin Island. Land use is mainly shoreline residences, vacation homes, and scattered small farms. Jarrell Cove is closed to shellfish harvest because of a private marina and boat moorage at the state park. The Washington State Department of Health **(**DOH) also has closure zones around sewage treatment plant discharges at Dougal Point, Walker's Landing, and Carlyon Beach (near Steamboat Island).

Figure PKP-1. Status and Trends of Fecal Pollution in Pickering Passage Through December 2001



Status and Trends: All but one of 25 stations was categorized as **GOOD** on each sampling date during calendar year 2001. Station 67 located north of the Hartstene Island Bridge ("p" in Figure PKP-1) was categorized as **BAD** on each sampling date. Trends were determined on six stations. Station 52 ("a" in Figure PKP-1) and Station 66 ("o" in Figure PKP-1) improved. Station 67 worsened. Three other stations didn't change. Trends at the remaining stations were not examined either because of short records or very low statistics. DOH listed Station 57 ("f" in Figure PKP-1) in its Early Warning System in early 2002. Figure PKP-2 shows graphs for selected stations.

Figure PKP-2. Fecal Pollution Over Time at Stations in Pickering Passage



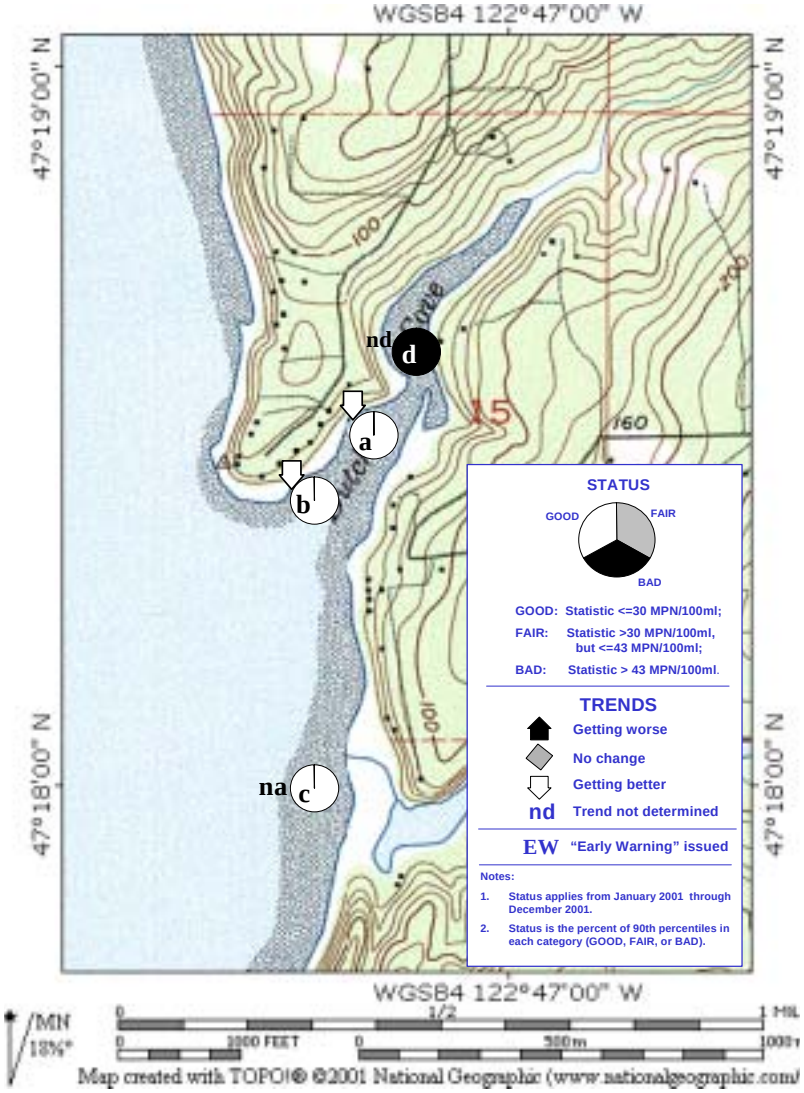
(Note: Trends were tested for statistical significance with Spearmans's R.)

Pierce County

Dutcher Cove

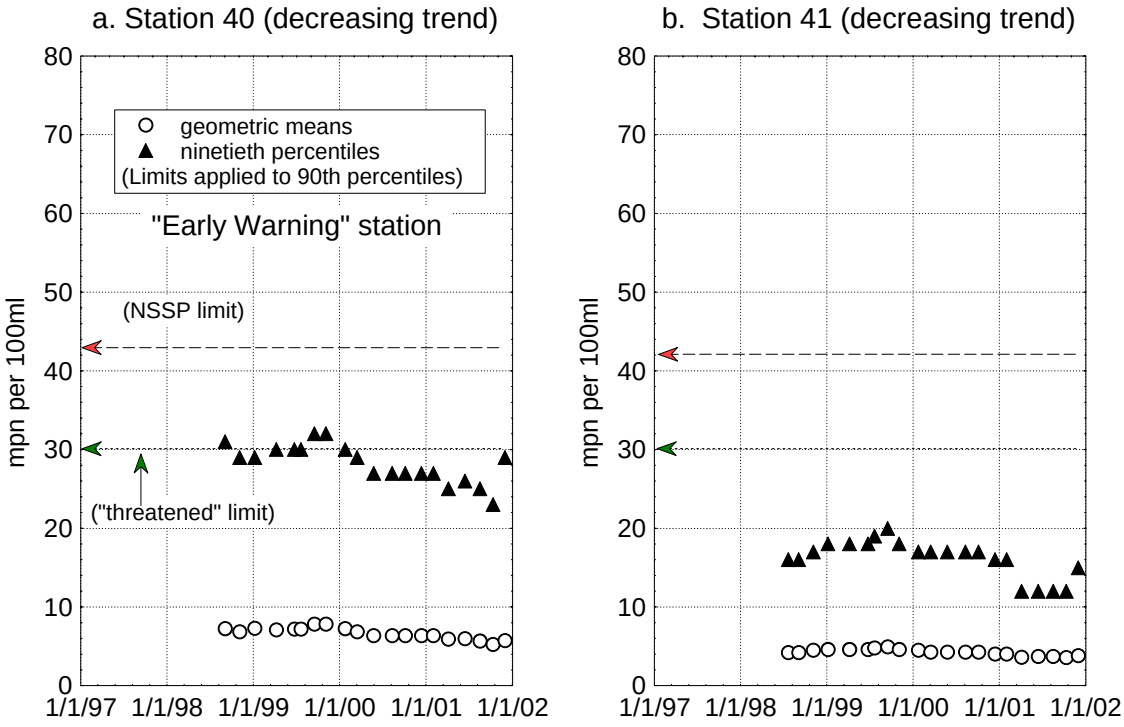
Background: In response to an application from a prospective shellfish harvester in Dutcher Cove, the Department of Health (DOH) conducted a shoreline survey in 1994 and began monitoring. The shoreline surveys uncovered three vacation properties that could potentially affect the proposed growing area. However, the sources were not deemed severe because they did not drain directly into the Cove. DOH classified Dutcher Cove Approved in 1997. In 2000 DOH received a request to add an additional 15 acres southeast of the spit. A new sampling station was added in the proposed area at that time.

Figure DCH-1. Status and Trends of Fecal Pollution in Dutcher Cove Through December 2001



Status and Trends: Stations 40-41 in Dutcher Cove ("a" and "b" in figure DCH-1) were categorized as **GOOD** on each sampling date in calendar year 2001. Station 42 outside and south of Dutcher Cove ("c" in Figure DCH-1) was also **GOOD**. The innermost station 552 ("d" in Figure DCH-1) was **BAD**. However, the status of stations 42 and 552 were tentative since their status is based on only a single value. Stations 40 and 41 improved significantly (Figure DCH-2). Trends were not determined on stations 42 and 552 due to short data record.

Figure 2. Fecal Pollution Over Time at Stations in Dutcher Cove



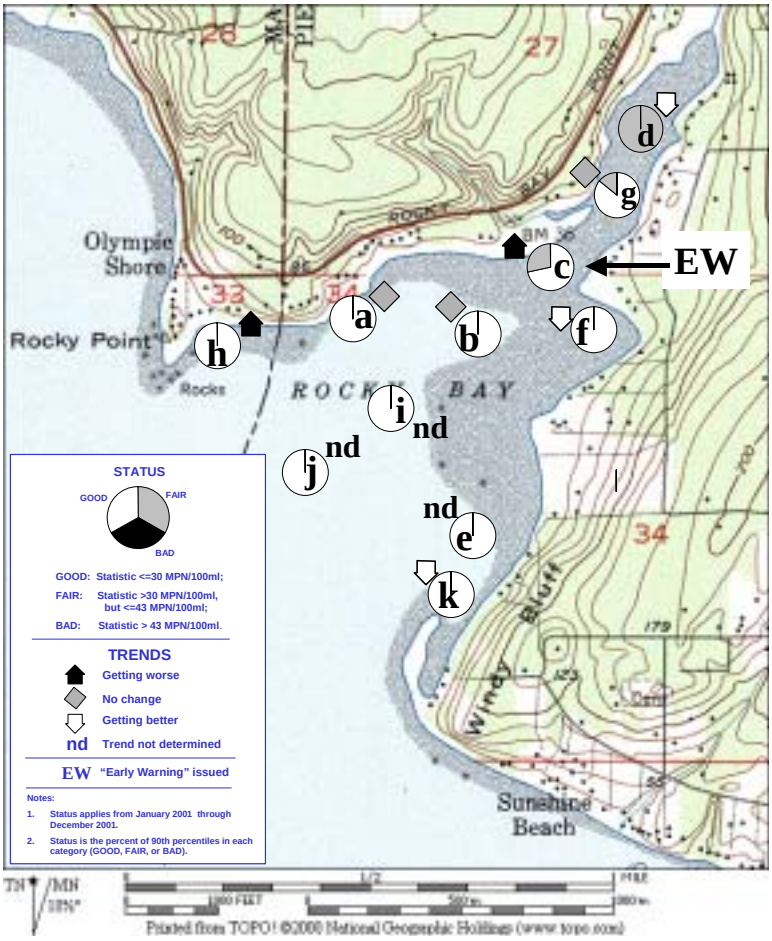
(Note: Trends were tested for statistical significance with Spearmans's R.)

Kitsap, Mason, and Pierce Counties

Rocky Bay

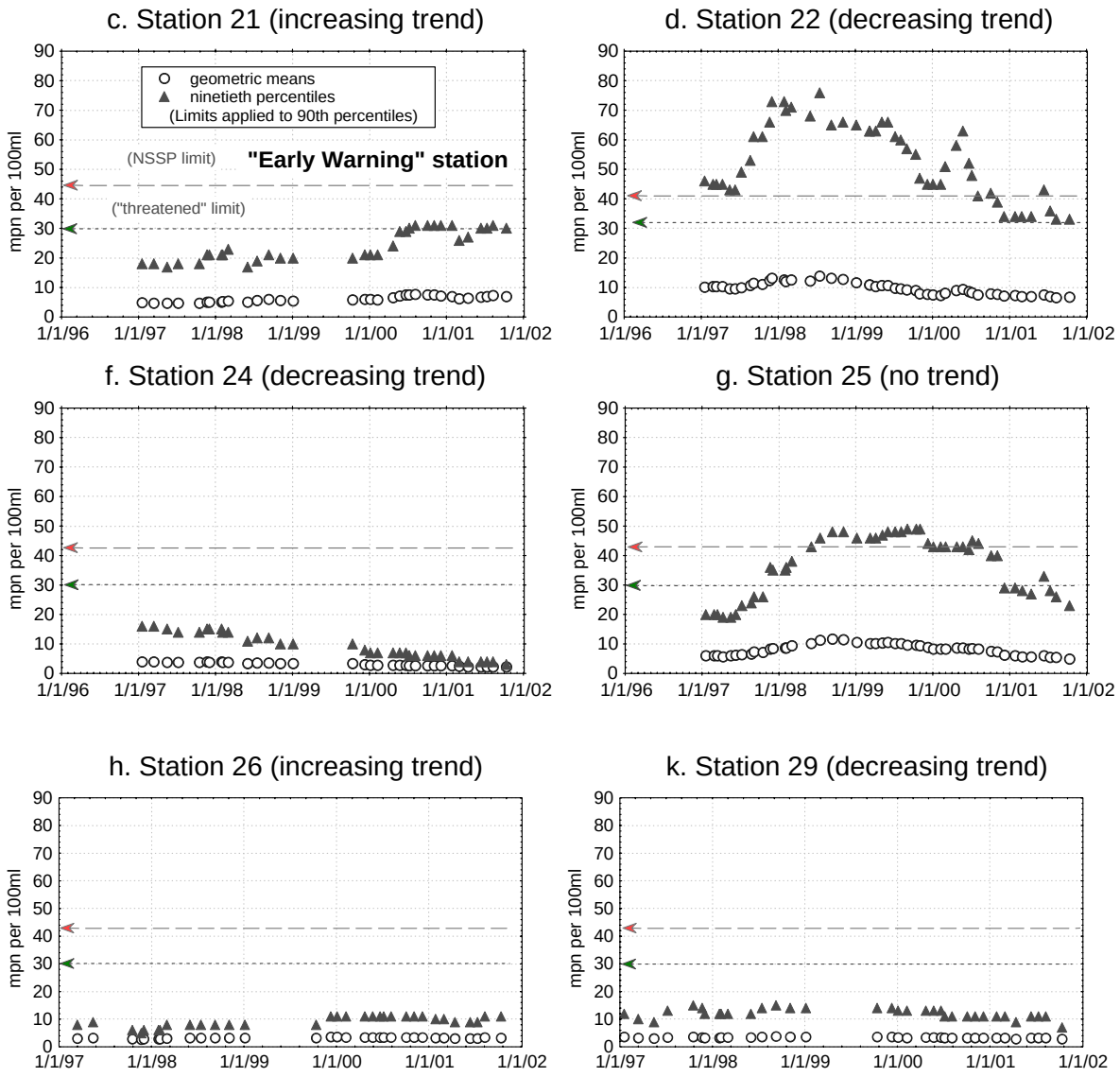
Background: In 1995 the Washington State Department of Health **(**DOH) downgraded inner Rocky Bay from **Approved** to **Prohibited**. Local and state agencies developed a Closure Response Strategy to carry out remedial work. All remedial activities involved community participation. Subsequent inspection of 80 shoreline on-site sewage systems revealed 4 failures. All failures were repaired. Runoff from State Route 302, which previously flooded on-site system drainfields, was diverted by swales and subsurface drainage. Grazing activity was minimal. In September 2002 most of Rocky Bay was returned to **Approved** status.

Figure RKB-1. Status and Trends of Fecal Pollution in Rocky Bay Through December 2001



Status and Trends: Eight stations in outer Rocky Bay were **GOOD** on each sampling date during calendar year 2001. DOH listed Station 21 ("c" in Figure RKB-1) in its Early Warning System in early 2002. Graphs of inner-bay stations 22 and 25 ("d" and "g" in Figure RKB-1) showed recent improvement (Figure RKB-2d, g). The trend at Station 26 ("h" on Figure RKB-1) was worsening statistics were very low (see also Figure RKB-2h).

Figure RKB-2. Fecal Pollution Over Time in Rocky Bay



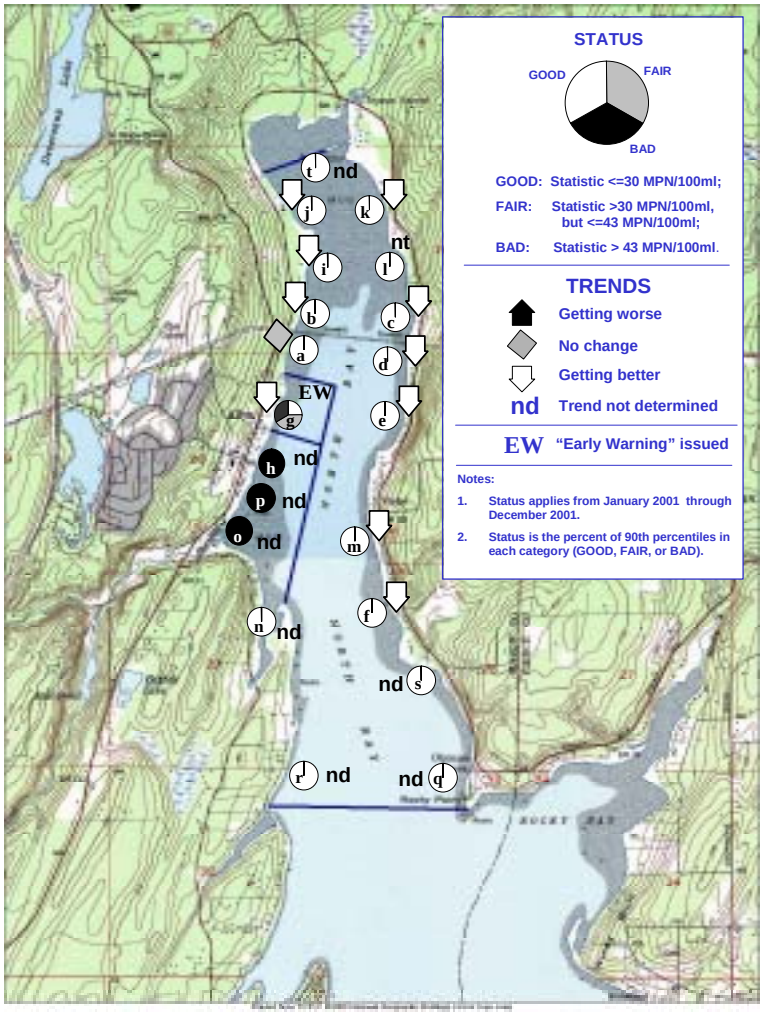
(Note: Trends were tested for statistical significance with Spearmans's R.)

Mason and Kitsap Counties

North Bay

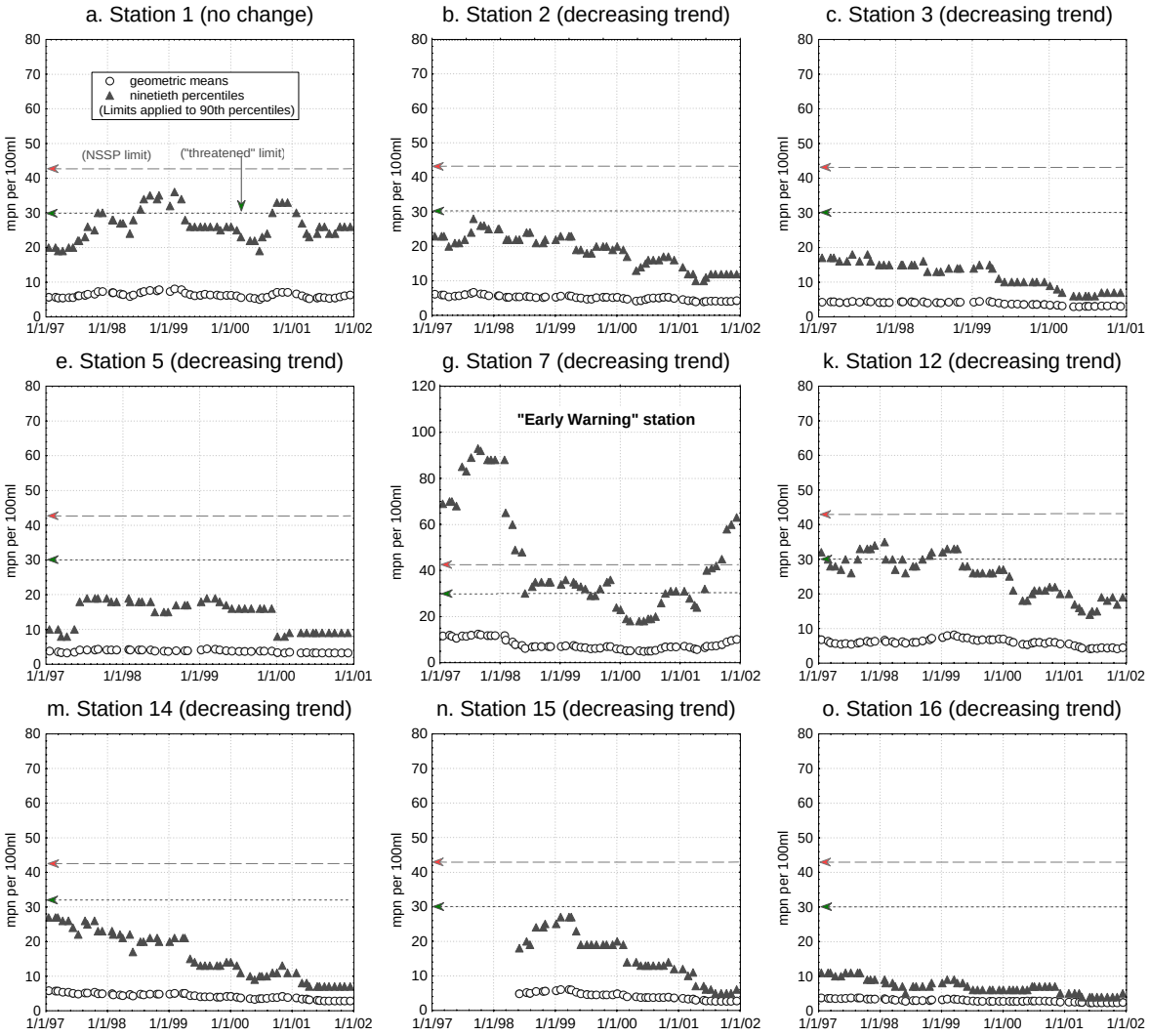
Background: In 1991, over 1,200 acres of shellfish beds were downgraded to **Prohibited**. Nearly one third of the on-site sewage systems in Allyn had failed. The Washington State Department of Health (DOH) declared a severe public health hazard. From May 1991 through October 1992, most failures were repaired. Later that year, part of the **Prohibited** area was upgraded to **Conditionally Approved**. A community sewage collection and treatment system has been built for several shoreline and upland communities. Most homes and businesses are now connected to the new system. In August 2002, most of the **Conditionally Approved** area was upgraded to **Approved**. A narrow area in front of Allyn and the extreme north end of the bay became **Unclassified**. A **Prohibited** zone remains in place at the mouth of Sherwood Creek south of Allyn.

Figure NRB-1. Status and Trends of Fecal Pollution in North Bay Through December 2001



Status and Trends: Fifteen of 20 stations were categorized as GOOD on each sampling date during calendar year 2001. Three recently added stations near Sherwood Creek were categorized as BAD. The status of Station 7 near Allyn ("g" in Figure NRB-1) was mixed. DOH listed Station 7 in their Early Warning program. Ten stations showed improved trend. Station 1 ("a" in Figure NRB-1) showed no significant overall change, although statistics have been volatile (see Figure NRB-2a). Trends for nine recently added stations were not available. Graphs of selected stations in Figure NRB-2 demonstrate overall improved conditions.

Figure NRB-2. Fecal Pollution Over Time at Stations in North Bay



(Note: Trends were tested for statistical significance with Spearmans's R.)

Clallam County

Dungeness Bay

Background: The Jamestown S'Klallam Tribe has farmed oysters in Dungeness Bay since 1965. Recreational harvesting also occurs in the inner bay. Water quality surveys in 1991-1992 revealed high fecal coliform levels in many watershed drainages. In 1996, the Washington State Department of Health (DOH) surveyed the shore and upland drainages. In 1997, citizens, Tribal and Clallam County staff began joint water monitoring. In April 2000, DOH downgraded 300 acres of Dungeness Bay to **Prohibited**. Local and state entities began Closure Response planning. DOH expanded the closure zone in April 2001. In May 2002 a Washington State Department of Ecology "total maximum daily load" (TMDL) study proposed numerical limits on fecal coliform loads from tributaries of the Dungeness River.

Status and Trends: Stations 104 and 113 ("b" and "k" in Figure DNG-1) were categorized as **BAD** on each sampling date in calendar year 2001. Most inner-bay stations were mixed. Three stations in outer (eastern) Dungeness Bay were categorized as **GOOD** on each sampling date. The pattern in Figure DNG-1 suggests a gradient of reduced pollution from the river into the inner bay. In early 2002 DOH placed eight stations on its Early Warning System list. Ten stations showed increased pollution trend. Figure DNG-2 shows graphs for most stations in Dungeness Bay.

Figure DNG-1. Status and Trends of Fecal Pollution in Dungeness Bay Through December 2001

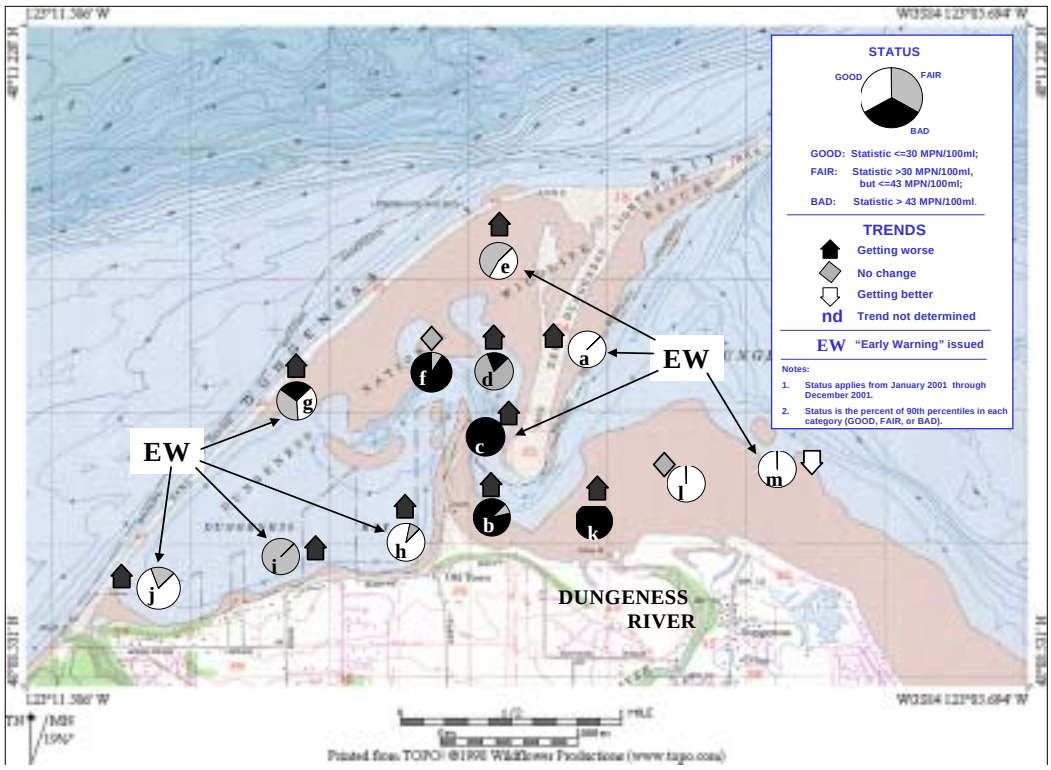
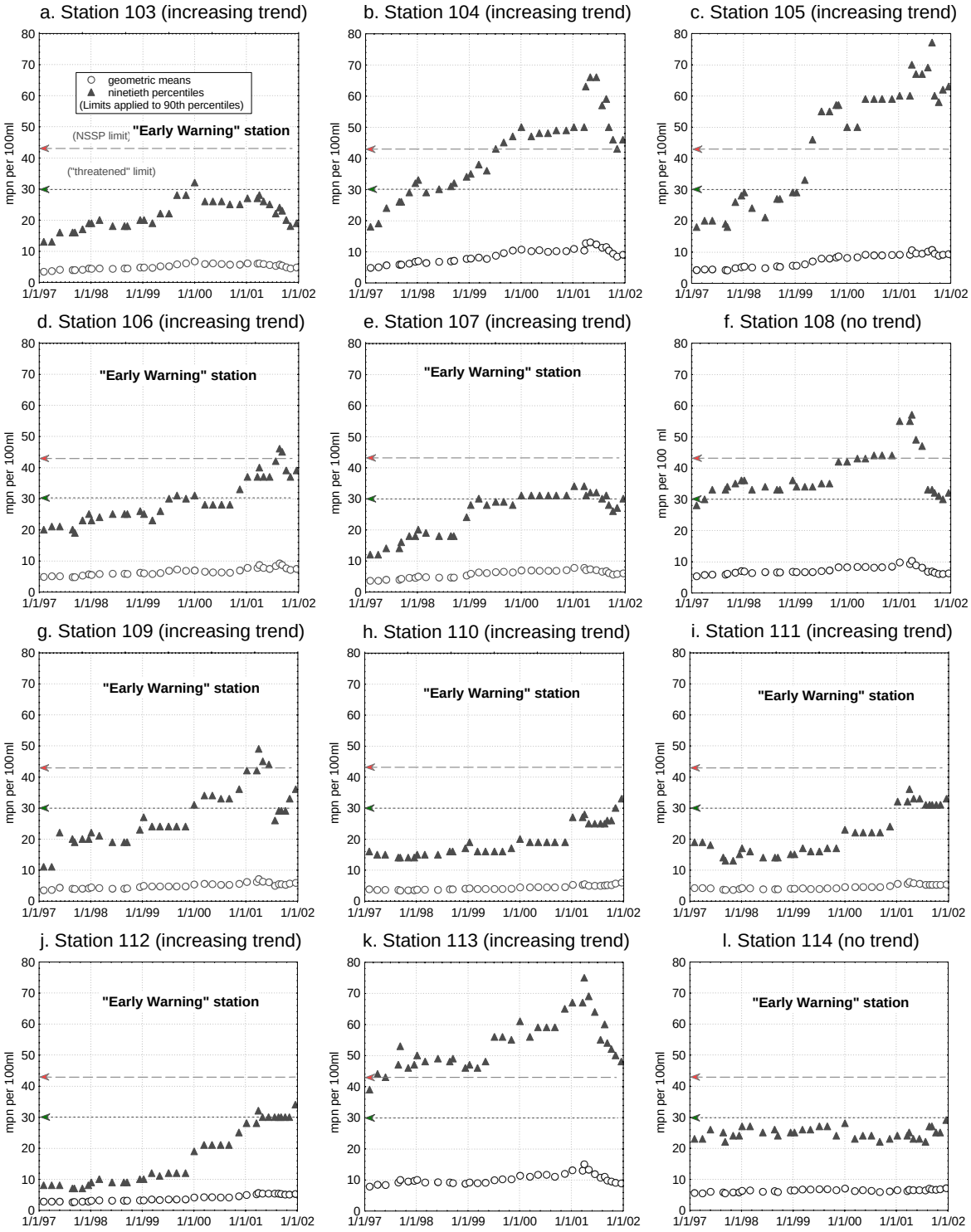


Figure DNG-2. Fecal Pollution Over Time in Dungeness Bay



(Note: Trends were tested for statistical significance with Spearmans's R.)

Clallam County

East Strait Of Juan De Fuca (Pysht River)

Background: In August 1996, the Washington State Department of Health (DOH) began a certification process at the request of the Lower Elwa S'Klallam Tribe along a 40-mile stretch of the Strait of Juan de Fuca from Dungeness Bay west to the Pysht River. DOH and the Tribe began a cooperative sampling program. In 1998, following a sanitary survey, the Pysht River and Deep Creek areas were classified **Approved**. However, a series of high fecal coliform results in late 1998 induced DOH to list Pysht River in its Early Warning System. Since shellfish harvest is not imminent, the area is currently considered **Inactive**.

Status and Trends: Twenty-nine of 31 stations were **GOOD** on all sampling dates during calendar year 2001. Station 140 near the mouth of Pysht River ("u" on Figure PYS-1) was **FAIR** on all dates. The status of Station 142 ("w" on Figure PYS-1) was mixed **GOOD** and **FAIR**. Trends were not done because the record was too short and 90th percentiles were generally too low to be of interest. Figure PYS-2 show graphs for stations 140 and 142.

Figure PYS-1. Status of Fecal Pollution Near Pysht River in East Strait of Juan de Fuca Through December 2001

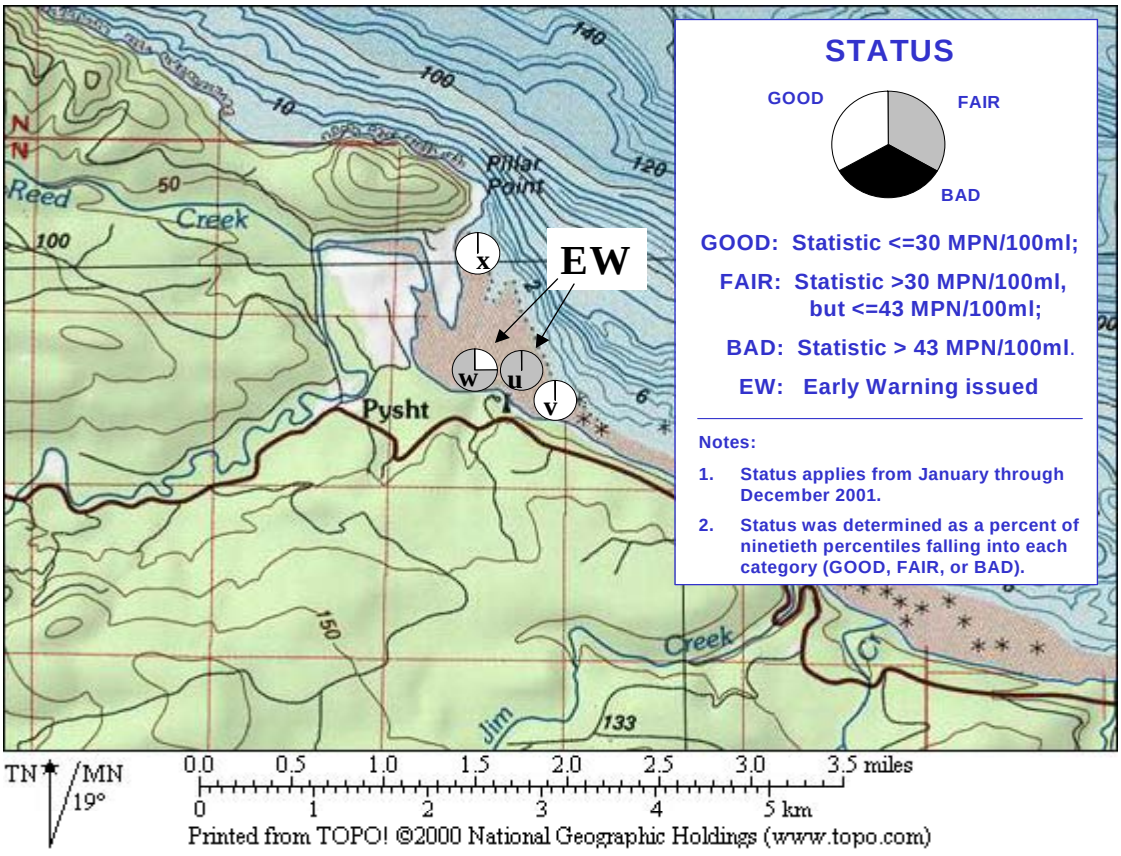
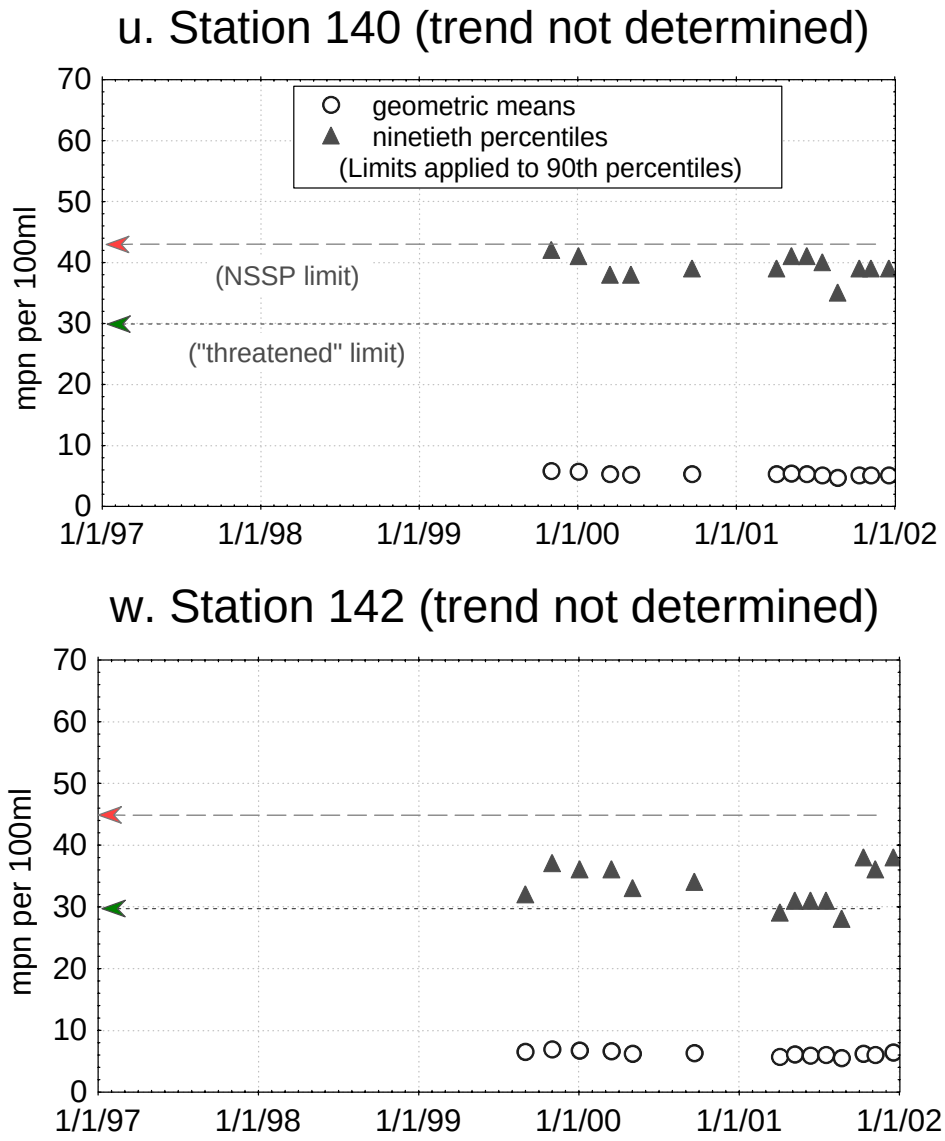


Figure PYS-2. Fecal Pollution Over Time Near Pysht River in East Strait of Juan de Fuca (both stations are "Early Warning" stations)

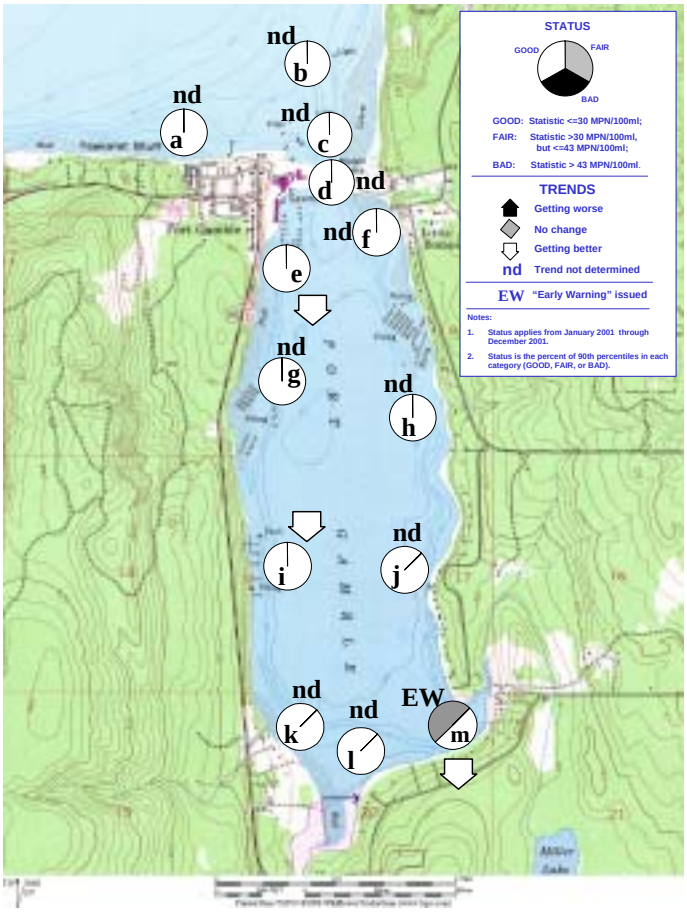


Kitsap and Jefferson Counties

Port Gamble

Background: The Port Gamble S'Klallam tribe harvests shellfish in Port Gamble. In July 1996, the Washington State Department of Health (DOH) downgraded about 20 acres of growing area in Cedar Cove at the south end of Port Gamble. Likely pollution sources were failed on-site sewage systems and agricultural practices in the Cedar Creek drainage. Sixteen failed on-site sewage systems were repaired and several small farms installed pollution controls. In April 1999, the Cedar Cove area was upgraded to **Approved**.

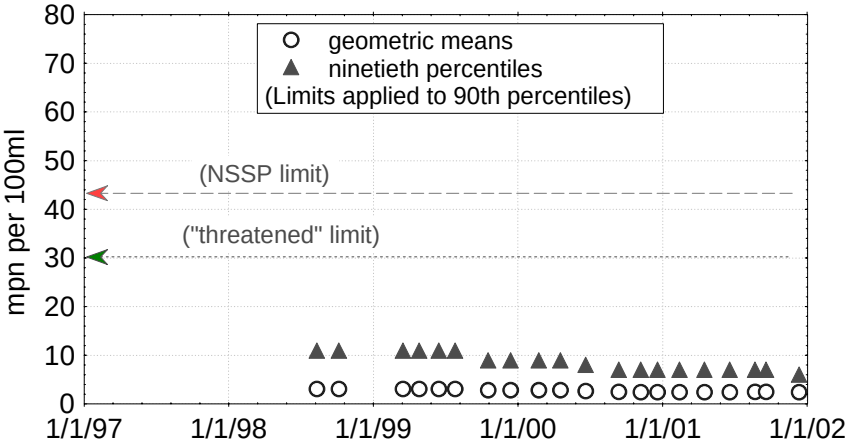
Figure PRG-1. Status and Trends of Fecal Pollution in Port Gamble Through December 2001



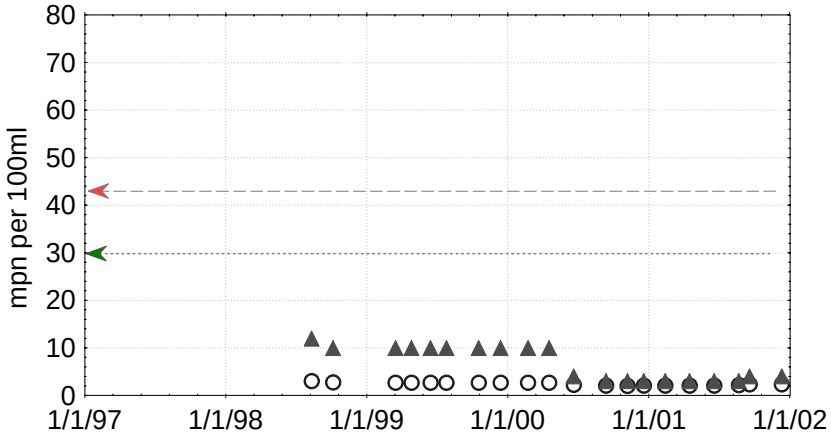
Status and Trends: All stations in the Port Gamble were categorized as **GOOD** on each sampling date in calendar year 2001, except Station 67 in Cedar Cove ("m" in Figure PRG-1). Station 67 had mixed **GOOD** and **FAIR** sampling dates. Stations 59, 63, and 67 (Figure PRG-1"e", "i", and "m") had improving trends. Figure PRG-2 shows graphs of the three stations. Station 67 is listed in the DOH Early Warning System.

Figure PRG-2. Fecal Pollution Over Time in Port Gamble

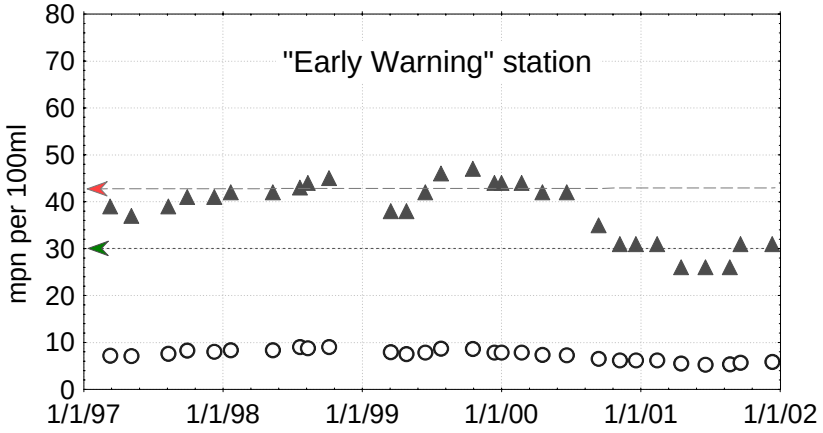
e. Station 59 (decreasing trend)



i. Station 63 (decreasing trend)



m. Station 67 (decreasing trend)



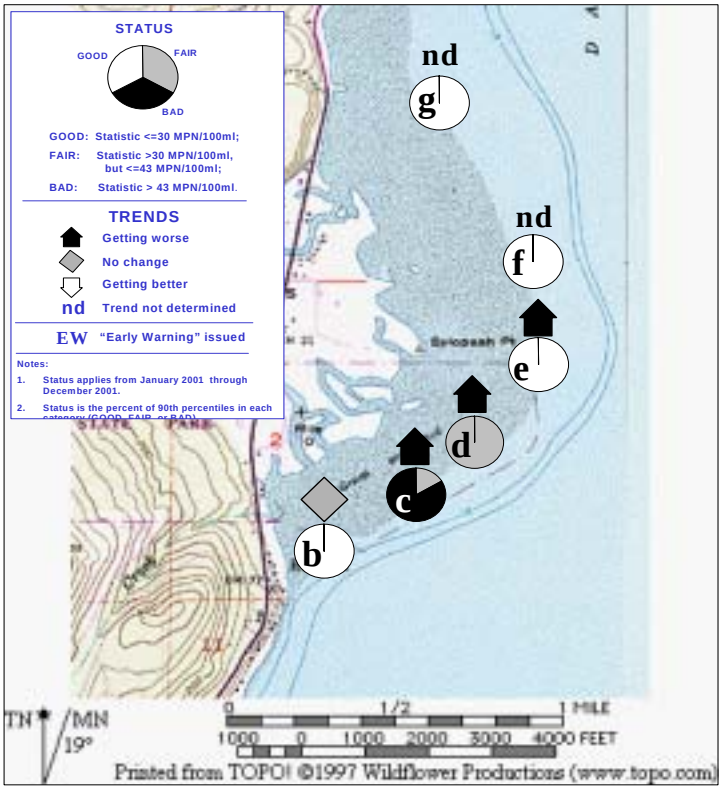
(Note: Trends were tested for statistical significance with Spearmans's R.)

Jefferson County

Hood Canal Area 3 (Dosewallips River Delta)

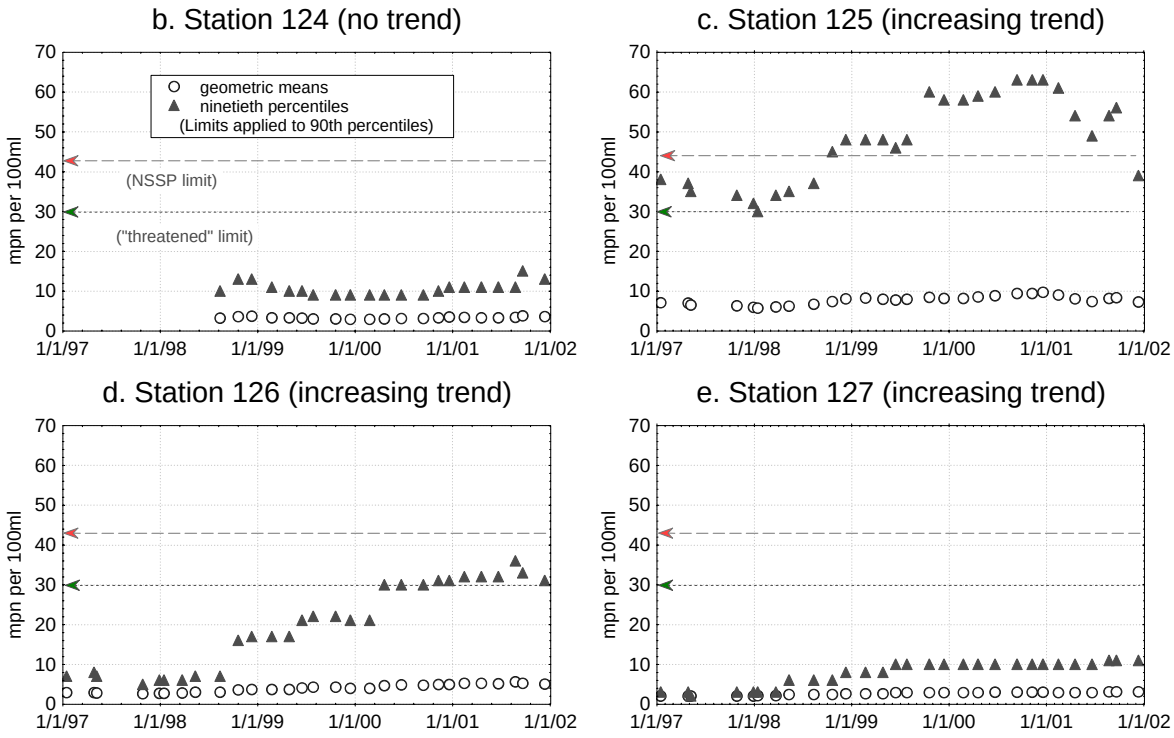
Background: Hood Canal Area 3 stretches along the west shore of Hood Canal from Point Whitney south to the Duckabush River. Most of Hood Canal Area 3 is **Approved**. The Washington State Department of Health (DOH) classified Pleasant Harbor (north of Duckabush River) **Prohibited** due to a marina. DOH downgraded the Duckabush River delta to **Restricted** in 1988. Pollution potentially came from on-site sewage systems, wildlife, and harbor seals. In 1989, DOH downgraded part of the Dosewallips River delta to **Restricted** due to harbor seals hauling out in one of several sloughs on the river delta. In June 1992, Washington State Parks authorities fenced off the slough and built a floating alternative haul-out in deep water off the mouth of the Dosewallips River. As a result fecal pollution decreased at the north end of the delta. DOH upgraded 30 acres on the north side of the delta to **Approved** in 1994. In 1998 the fence was partially damaged. Some harbor seals have been seen in the slough. Repair awaits permits and funding. In early 2001 the Duckabush River delta was upgraded based on improved water quality, and the approach to Pleasant Harbor was given a seasonal **Conditionally Approved** classification.

Figure HD3-1. Status and Trends of Fecal Pollution at the Dosewallips River Delta Through December 2001



Status and Trends: Seventeen of 20 stations in Hood Canal Area 3 were categorized as **GOOD** on each sampling date in calendar year 2001. Station 126 ("d" on Figure HD3-1) was categorized as **FAIR** on each date. Station 125 ("c" on Figure HD3-1) had mixed and mostly **BAD** dates. A new Station 142 (near Duckabush River delta) was **FAIR** (based on a single statistic). Station 124 ("b" on Figure HD3-1) showed no trend. Stations 125-127 showed upward trends (Figure HD3-2). Trends were not determined on the rest of the stations because of very low pollution.

Figure HD3-2. Fecal Pollution Over Time at Dosewallips Delta



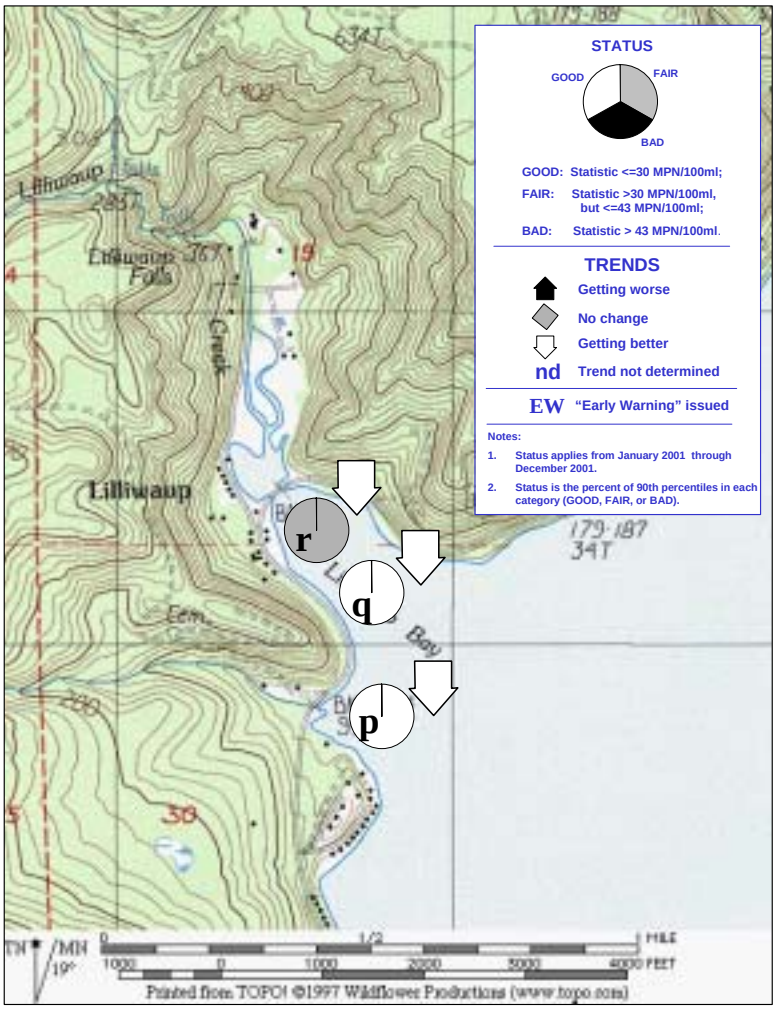
(Note: Trends were tested for statistical significance with Spearman's R.)

Mason County

Hood Canal Area 5 (Lilliwaup Bay)

Background: Hood Canal Area 5 is **Approved** except for Lilliwaup Bay, which lies on the west shore near in the center of Hood Canal Area 5. In early 1997, due to increased fecal coliform pollution, shellfish growers voluntarily stopped harvesting in Lilliwaup Bay. The Mason County Health Department carried out sanitary surveys along the shoreline. The Washington State Department of Health (DOH) and the Washington State Department of Ecology expanded sampling to include the associated upland watershed. Lilliwaup Bay was downgraded from **Approved** to **Prohibited** in September 1998. An Ecology study in 1999 concluded that most fecal pollution came from upland private lands and wildlife during in the wet season.

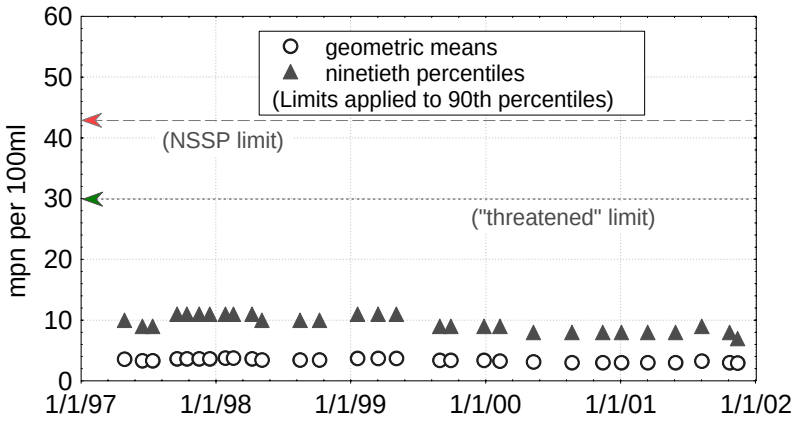
Figure HD5-1. Status and Trends of Fecal Pollution in Lilliwaup Bay Through December 2001



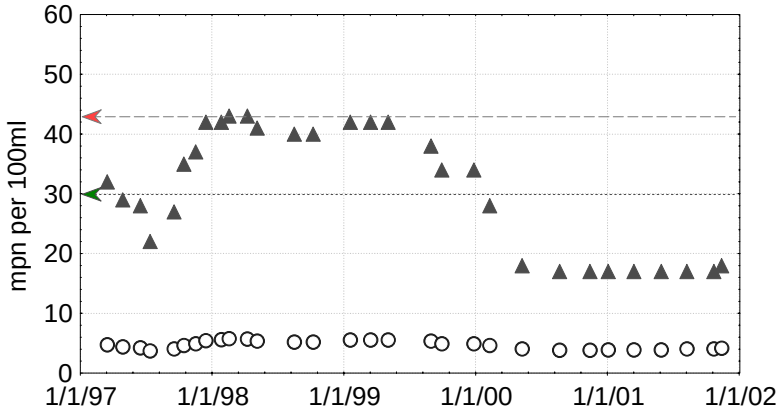
Status and Trends: Twenty-six stations were evaluated in Area 5. The status of 25 stations was categorized as **GOOD** for each sampling date during calendar year 2001. Station 186 ("r" in Figure HD5-1) in Lilliwaup Bay was categorized as **FAIR** on each sampling date. Stations 184, 185, and 186 ("p", "q", and "r" in Figure HD5-1) showed significant reduction in fecal pollution (see Figure HD5-2). Data at the remaining sites were too few or too low to justify trend analysis.

Figure HD5-2. Fecal Pollution Over Time at Lilliwaup Bay (Hood Canal 5)

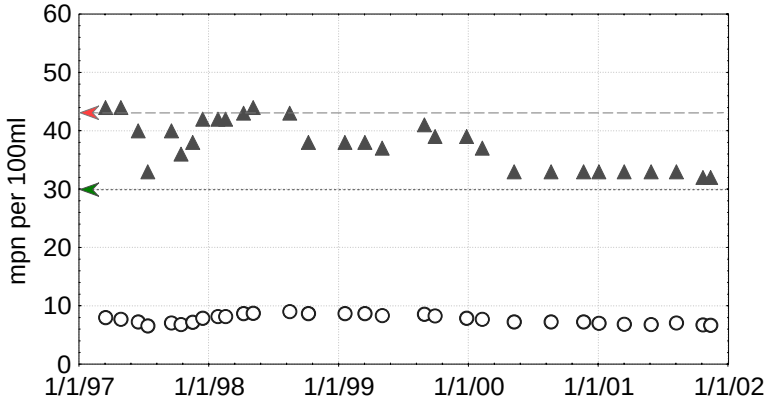
p. Station 184 (decreasing trend)



q. Station 185 (decreasing trend)



r. Station 186 (decreasing trend)



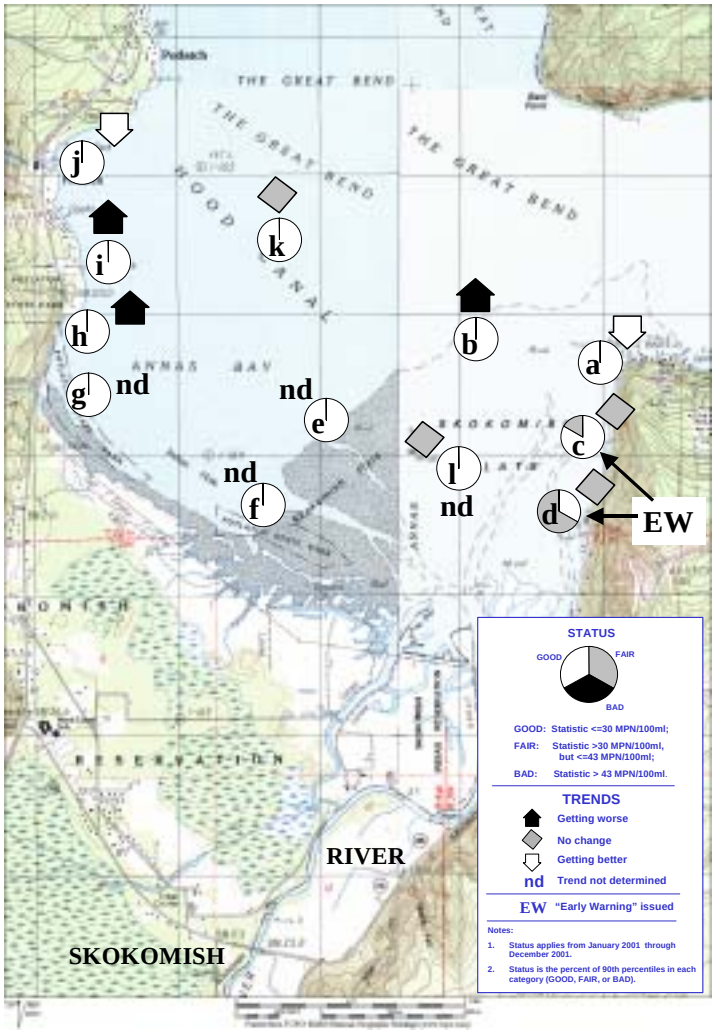
(Note: Trends were tested for statistical significance with Spearman's R.)

Mason County

Annas Bay (Hood Canal)

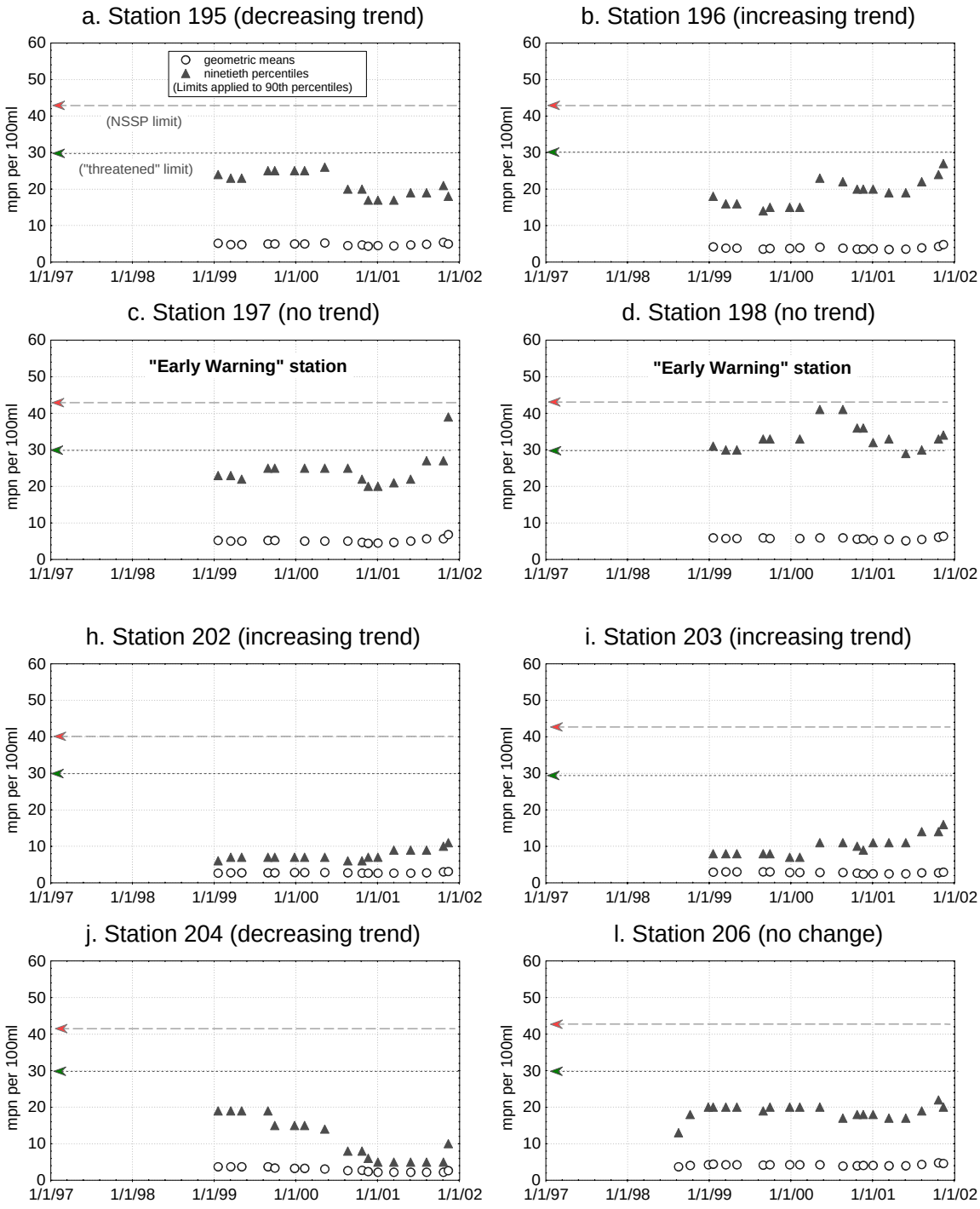
Background: In late 1995, the Washington State Department of Health (DOH) began emergency closures of Annas Bay during flooding of the Skokomish River. In 2001 the Washington State Department of Ecology completed a "total maximum daily load" (TMDL) analysis of fecal coliforms from the Skokomish River and tributaries. The study indicated a little more than half the pollutant load came from the lower floodplain of the Skokomish River and associated tributaries. A water cleanup plan proposed reductions in this part of the Skokomish River. A DOH shoreline survey of Annas Bay in 2001 indicated no direct or indirect pollution sources present. Annas Bay is now **Approved**, although DOH imposes periodic flood closures.

Figure ANB-1. Status and Trends of Fecal Pollution in Annas Bay Through December 2001



Status and Trends: Ten of 12 stations were categorized as **GOOD** on each sampling date during calendar year 2001. Station 198 ("d" in Figure ANB-1; nearest station to the mouth of the Skokomish River) was categorized as **FAIR** on most sampling dates. Station 197 just to the north ("c" in Figure ANB-1) was categorized as **GOOD** on most sampling dates. DOH placed both of these stations on its Early Warning list in early 2002. Three stations showed increasing trends, two decreased, and four did not change significantly (Figure ANB-1). Statistics for the remaining stations were too low to justify trend analysis. Figure ANB-2 shows graphs of selected stations.

Figure ANB-2. Fecal Pollution Over Time in Annas Bay



(Note: Trends were tested for statistical significance with Spearman's R.)

Mason County

Hood Canal Area 9 (Lynch Cove)

Background: The Washington State Department of Health (DOH) classified all of Hood Canal Area 9 (Lynch Cove) as **Prohibited** in 1993. Later, 570 acres of the south shore were classified "**Restricted**" to allow relay of shellfish to **Approved** waters. In 1996, DOH upgraded 500 acres of the **Restricted** area to **Approved** following an intensive on-site sewage system repair program carried out by Mason County. Part of the north shore also was upgraded to **Approved**. DOH and Mason County jointly conducted a shoreline survey in 2000. No direct or indirect fecal sources were found. In November 2001, a "total maximum daily load" (TMDL) study by the Washington State Department of Ecology recommended fecal load limits for the Union River near Belfair. In late 2001, Mason County discovered that the on-site sewage system serving Belfair State Park had failed. The Park is currently repairing the system.

Status and Trends: Fourteen of 20 stations were categorized as **GOOD** on each sampling date in calendar year 2001 (Figure HD9-1). Four stations off Belfair State Park were categorized as **BAD** on each sampling date. Stations 279 and 286 ("l" and "s" on Fig. HD9-1) were mixed. Four stations improved and one was unchanged. Trends were not done on the rest due to short record or low pollution. DOH placed Station 286 on its Early Warning System list in early 2002. Figure HD9-2 has graphs of selected stations.

Figure HD9-1. Status and Trends of Fecal Pollution in Hood Canal Area 9 Through December 2001

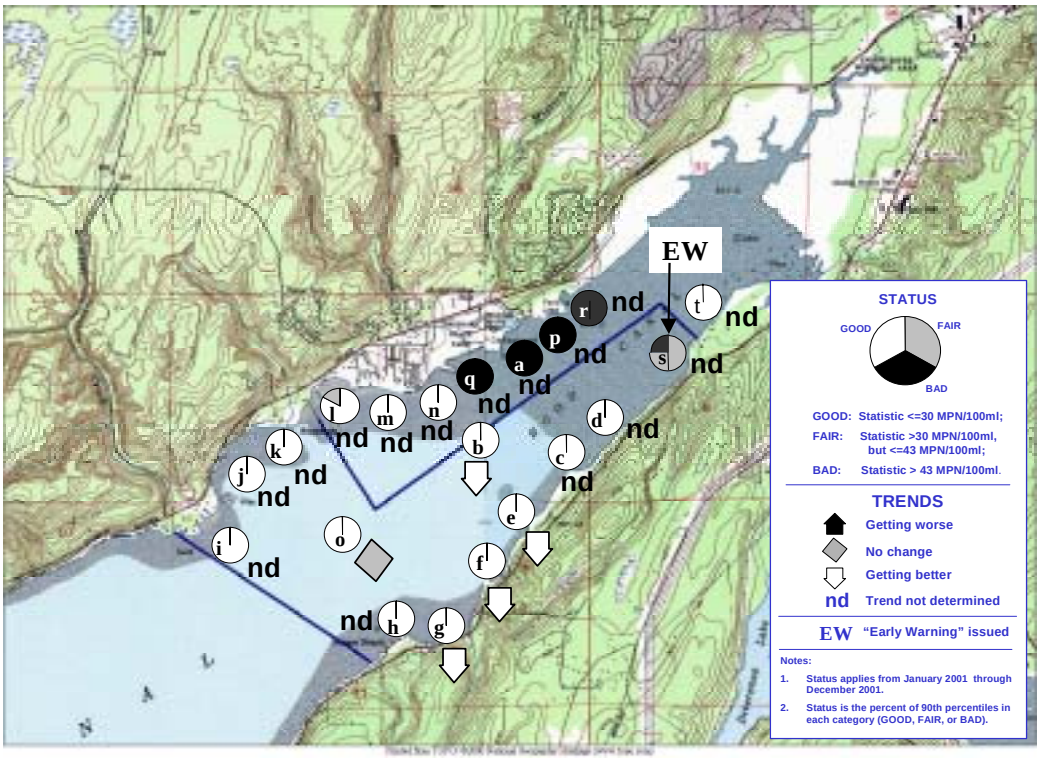
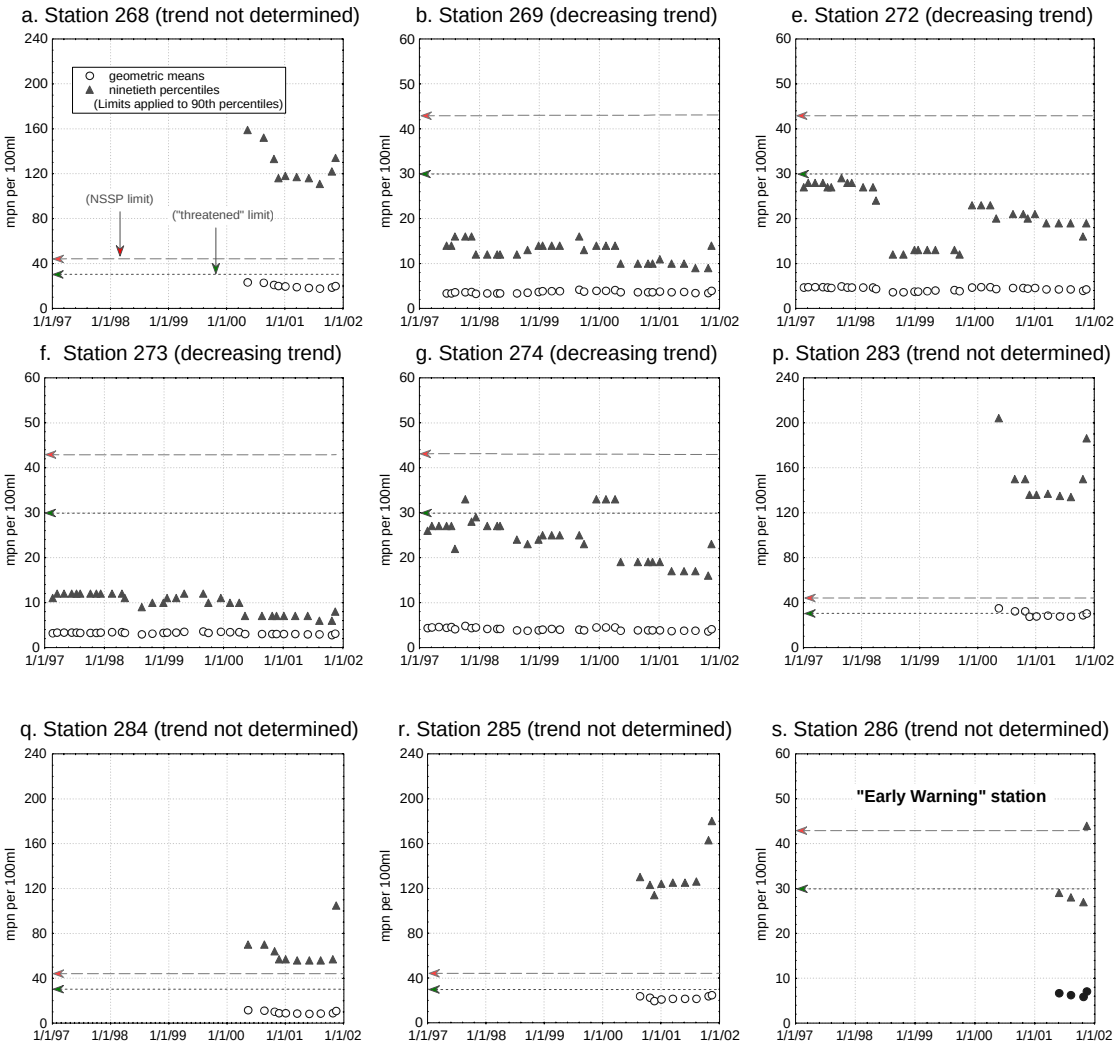


Figure HD9-2. Fecal Pollution Over Time in Hood Canal Area 9



(Note: Trends were tested for statistical significance with Spearman's R.)

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